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The Forty-third Annual Meeting of the American Association of Economic Entomologists, Section of Apiculture

December 29, 1930

The meeting was called to order by the chairman of the section, R. L. Parker, at 1:30 P.M., in Room 24, Electricity Building, Case School of Applied Science, Cleveland, Ohio.

CHAIRMAN: An announcement will be made by A. F. Burgess, the secretary of the Association of Economic Entomologists.

A. F. BURGESS: Through some misunderstanding, a number of titles for the section of apiculture were sent to me instead of the secretary of this section, Mr. F. B. Paddock. This caused a delay so that some of the papers could not be announced in the programs. I would suggest that another year the titles be sent in a little earlier and that they be sent direct to the secretary of the section of Apiculture.

CHAIRMAN: Due to the absence of the secretary, F. B. Paddock, I wish to appoint E. J. Anderson of Pennsylvania as acting secretary.

I also wish to appoint two committees; the committee on resolutions to be composed of: E. L. Sechrist, Chairman, E. J. Anderson and G. E. Marvin; and the committee on nominations: E. F. Phillips, Chairman, G. M. Bentley and W. E. Britton.

CHAIRMAN: The address by the chairman will be given later in the program. We will now proceed to the first paper as part of the Symposium on Honey which will be given by Dr. E. F. Phillips.

THE PRESENT STATUS OF HONEY INVESTIGATIONS

By E. F. PHILLIPS, *Cornell University, Ithaca, New York*

ABSTRACT

A brief sketch is given of investigations on honey and of the needs of the future. Special emphasis is placed on the need of studies of the physical properties of honey, which promise to be the most helpful line of investigations from the point of view of preparing honeys for market.

There is an extensive literature on honey which is of inestimable value. To undertake an adequate discussion of this work assumes more or less familiarity with all of it, and on this basis there is probably no person qualified for the task. If future work is to be conducted along lines which are most profitable and practical, a stock-taking is desirable, but to do this thoroughly is a large task and the analysis should be critical, whereas the present effort presumes to be a mere sketch.

The scientific literature on honey may roughly be grouped into three interlocking classes, (1) chemical, (2) biological, and (3) physical. There is also a large literature based on experiences of beekeepers and packers and on uses of honey in cooking, baking and beverage manufacture, all of which must for the present be omitted. Naturally from the experience of all the years during which honey has been prepared for sale and put to use, certain practical facts about it have been learned, but if the discussions on honey in the beekeeping literature are examined critically, it is found that the majority of the statements are either untrue or need qualification. It is to be regretted that ostensibly scientific literature has added to or perpetuated such errors.

The early work on honey gave special attention to chemical analyses dealing chiefly with the carbohydrates, and there is an extensive literature which gives a comprehensive knowledge of the relative proportions and variations of these compounds. Since detection of sophistication is always a vital problem, many tests have been devised for such use, the early ones being based chiefly on changes occurring in the sugars. There is also considerable literature on the composition of honey-dew honeys, coming from those European countries where this is an inportant part of the crop. Frl. Beutler's study on nectar sugars is helpful in understanding the sugars of honey. The discovery of melezitose in honey-dew honey by Hudson and more recently by Nottbohm and by Burnside and the finding of maltose as a common minor ingredient by Elser are further contributions, in which class might also be included the earlier discovery of the sugar alcohols, mannite and dulcite, in honey-dews.

Chemical methods have been refined to include microchemical studies of the mineral constituents by Elser and others. Still more recently studies have been made of constituents which occur in honeys in most minute amounts, in which group may be included work on the organic acids of honey which has helped to clear up the confusion arising from the routine practice of many chemists in measuring the acidity of honeys in terms of formic acid. This custom seems to have been based on the amusing assumption that this acid is injected into honey by the sting of the worker bee, a theory which was carried to its most absurd length in

the "sting-trowel" theory of Clarke. The effect of tannic acid on iron in causing discoloration of tinned honeys is a practical application of work on honey acids. The recent crystallization by Nelson of the flavoring material of orange honey is a notable advance. Work on the nature of the coloring materials of honey, largely unpublished, is another refinement in chemical work. There is also a large literature on supposedly poisonous honeys, running back for years, characterized mainly by lack of accuracy. On the whole the chemical work is excellent.

Among biological studies, most attention has recently been given to the enzyme contentof honeys. The German work was stimulated by the necessity of finding some test to differentiate genuine honey from spurious syrups sold during and after the War as honey. Having found that honey contains diastase while artificial honey does not, it was natural that emphasis should be placed on this discovery by German beekeepers who were faced with a poor market. It is to be regretted that these tests were misused as a means of keeping genuine American honeys out of the German market, and while the present German tariff on honey seems excessive, it is more commendable to impose a prohibitive duty than to misdirect scientific tests to prevent competition. Apparently American honeys are often strained better than are some German honeys, so that their diastase content is lowered. Pollen grains are probably the chief source of this enzyme in honey, and their removal merely makes honey better. The unreliability of the supposedly quantitative tests for diastase in detecting the purity of honey has been shown by Freeborn and Vansell and by others.

Similar studies, free of commercial complications, have been made of other enzymes in honey. Gillette's unpublished work on catalase is in this class. There is still some confusion as to the sources of the various enzymes. While these mysterious substances are useful as trade marks of purity, the importance of their presence still remains to be demonstrated, and they are of doubtful importance for human food.

Several tests have been made for the presence of various vitamins in honeys. The more recent and more accurate work indicates that if vitamins are present, they are in scant amounts, perhaps derived again from included pollen grains. While beekeepers might welcome the opportunity to advertise honey as a vitamin source, a failure to find them does not detract from the merits of honey as human food. The study of precipitins of honey by several investigators is another biological study of some interest which has attracted little attention and which has not been put to practical use. Investigations of pollen inclusions have been made by several workers, primarily for the purpose of fixing the floral

source of honeys, although for this purpose the work appears to be virtually valueless. Studies of other solid inclusions, mostly organic, have also been made.

Honey fermentation is also a biological problem. The enlargement of commercial honey production has necessitated storing honey from one year to the next, and the problem of preventing fermentation has assumed great importance, especially on this continent. Most honey buyers examine every can of honey bought after about March 1 of the year following production to avoid fermentation losses. Pugh's unpublished work on Ontario honeys indicates that honeys stored for one year show an average loss from this cause of 5%, while those stored for two years show an increase of loss to 25%. Such loss is intolerable, and it is not surprising that several workers have independently attacked the problem. Much of the work so far done deals with the taxonomy of sugar-tolerant yeasts causing honey fermentation, but the practical problem is either to destroy or to inhibit the growth of these yeasts. Since these yeasts may enter through nectar, honey fermentation is an ever present danger to the handler of honey.

Thin honeys ferment more readily than do well ripened honeys, and this fact led to the assumption that the probability of later fermentation in any honey might be predicted by a determination of its density in terms of specific gravity. The method has proven valueless, for Pugh found no relation between specific gravity and fermentation, if we disregard such honeys as are too thin to put on the market. Neither could he detect a correlation between fermentation of Ontario honeys and floral source, color grades or climatic conditions at the time of production. If a larger area had been included, it might have been found that extreme dryness of the atmosphere at the time of production has some effect, yet it is known that western honeys of high density ferment.

The relation of crystallization of honey to fermentation has complicated the problem, since the formation of sugar crystals in honey produces a higher moisture content in the liquid phase of granulated honeys. This greater water content is not due to the "giving off" of water by the crystals, as has recently been suggested, but is due to the fact that when dextrose crystallizes from a water solution, one molecule of water is incorporated with each molecule of dextrose, forming dextrose hydrate. This moisture amounts to 9.09% by weight of the crystalline material. This lowered moisture content of the solid phase, in relation to the water content of the honey as a whole, provides conditions for fermentation, since the liquid phase always is the major portion of "solidly" granulated honey.

While a relationship between crystallization and fermentation has been recognized, the facts have sometimes been misinterpreted. After fermentation has progressed for a time, a partial separation sometimes occurs between the solid and liquid phases of honey, due to the presence of fermentation products. It has been stated that fermentation occurs after separation, whereas it usually begins in "solidly" granulated honeys. Emphasis has also been placed on a higher water content in the tops of jars, it being assumed that this favors fermentation, but this difference is apparently due only to the separation which occurs when liquid honeys of different densities are placed together without thorough blending. Fermentation sometimes occurs at the top of a container more than elsewhere, but since the yeasts do not require oxygen for growth, it may occur throughout the container.

Fermentation rarely occurs in liquid honey, and does not occur in honeys that have been liquified by the methods used in bottling honey, unless the product is later exposed to a moist atmosphere for a considerable time. The effect of sugar concentrations in protecting yeasts from destruction by heat has been demonstrated by Rahn, and this must be considered in determining proper minimum temperatures for this purpose. It is, therefore, in honey stored in tin containers that serious fermentation occurs, for such honeys usually granulate after packing.

The heating of honey is so simple a method of preventing fermentation that it might be concluded that all that is necessary would be to heat honey at the time of putting it into containers. The destruction of enzymes by heat has already been mentioned, but as their value is insignificant, this need not to be considered for the domestic trade. This is by no means the most serious objection to this method. After heating, honey crystallizes less rapidly than does unheated honey, and when crystals form, they are coarse, imparting to the honey an inferior flavor. The true honey flavor is neither lost nor destroyed by proper heating, since it is fully recoverable, but honey buyers appear to be unfamiliar with some of the simplest facts about honey and usually refuse to pay full market price for coarsely granulated honeys. Beekeepers of New York and Pennsylvania every year have prices cut on high grade buckwheat honey merely because it is coarser than usual. Until buyers discontinue the erroneous practice of judging honeys by taste, in whatever physical state they are received, it will be unwise for beekeepers to heat honey.

These and similar obstacles have led to suggestions for the use of chemical preservatives or for the use of cold storage for honeys as substitutes for heating. Beekeepers would not countenance the use of pre-

servatives without declaration, and their declaration would injure the markets. To be compelled to keep honey in cold storage would so increase expenses as to destroy all profits from the beekeeper's operations under present price conditions. The one practical means of preventing fermentation seems to lie in proper application of heat, followed by proper handling of honey so as not only to prevent injury but if possible actually to enhance its merit Fortunately this is possible.

A discussion of physical work on honey must deal chiefly with deficiencies. There are some interesting papers on physical properties of honey, mostly concerned with phenomena in which waves of radiant energy are involved, and some of this work has been useful in devising color standards for extracted honey. Unfortunately essential parts of this work are unpublished.

It is deeply regrettable that there are no thorough studies of viscosity, surface tension, crystallization phenomena, electrical charge of honey colloids, diffusion, relations of specific gravity to other physical phenomena and the like. There are two small papers on viscosity, neither of which give us much help, but they are a start in the right direction. Honey at ordinary temperatures is essentially a solution of sugars, partly supersaturated and containing also a considerable number of other important constituents in small amounts which markedly affect its physical characteristics. Jackson and Silsbee have recorded important facts on the effect of one honey sugar on the saturation point of another in a water solution, but leave out of account the other constituents of honey.

It so happens, whether or not this is desirable, that the physical condition of a honey is more important from the standpoint of marketing than the chemical composition. The physical state has a marked effect on the flavor of honey, and it is important to attain for our honeys that physical condition which will enhance the flavors. It then seems vitally important that more thorough studies be made of the physics of honey, primarily as a basis for practice. Recent work has vastly magnified the importance of such work, and points the way to greater progress in the future.

To illustrate this need, it is a serious problem in packing honey to prevent the formation of crystals in bottled honey. Methods have been devised to prevent crystal formation for months and in some blends for years, but all too often the honey is ruined as a first-class product by the excessive heating to which it is subjected. A study of the conditions of crystal formation in honeys shows that it is as easy to retard subsequent growth of crystals by safe as by improper heating, yet a lack of suitable

studies has led to the unfortunate practices of the honey trade whereby much bottled honey is rendered inferior.

As a rule, a honey that has once been heated will crystallize in time, but with coarse, rough crystals. The reason for this difference, which is an exceedingly simple one, has not been known to packers. Since heating of honey has been a common practice and since later granulation is of a highly undesirable type, the easiest way to put honey on the market has been in liquid form. This selection of the path of least resistance is probably responsible for the fact that the public prefers liquid honey to granulated, a situation which does not exist in other countries where more honey per capita is consumed.

Any unprejudiced judge of honey knows that the same honey in liquid, finely granulated and coarsely granulated form carries different flavors for each condition. The reasons for these differences lies partly in the physiology of taste and partly in our psychology, and the student of honey does not concern himself with these problems. It is necessary only to know that a finely granulated honey is unquestionably the best of the three. But since by ordinary methods of handling, this condition has not been readily attainable, packers have been satisfied to supply the market with less desirable liquid honey.

These statements are adequate to indicate that one of the things most needed is accurate information and suitable methods to control the physical condition of honey. The immediate economic value of such studies is indicated by the work to be reported later in this meeting by Mr. Dyce. It has been found to be a simple matter to control crystal formation, once the theory is understood, and this has been done not by the devising of entirely new methods but by the application to honey of methods long ago worked out for the crystallization of other products. Since by this process, fermentation is entirely controlled, the method assumes a double importance.

The materials which go to make up honey are in liquid, solid and colloidal states. The liquids are rather well known and the solids have been studied considerably. The striking Tyndall effect when light passes through honey indicates that there is a considerable colloidal content, but the nature of these colloids remains undetermined, although obviously some or all of them are dextrins. Since honey dextrins are not utilized by adult bees as food, these have a double interest.

The clarifying of honey is one of the most difficult problems of the honey packer, but the clarification at which he at present aims is merely the removal of larger solid particles and minute air bubbles. Since it is ordinarily so difficult to remove these, it may seem foolish to suggest the

removal of the ultramicroscopic colloids, yet this is by no means impossible. The recent work of Lathrop and Paine is a start in this direction, and other unpublished work gives promise of practical methods.

Extracted honey in glass sells more on appearance than on quality, which is perhaps to be regretted but the fact remains. The removal of all larger particles and all or most of the colloids would greatly enhance the appearance of liquid honey without reducing its merit, and if the colloids are removed, the larger particles and bubbles also disappear. Before prophesying commercial success, many methods must be tried on a large scale. It is to be noted that other industries have been faced with similar problems which have been solved, so there are no inherent impossibilities in this effort. Beekeeping has to a large degree failed to take advantage of methods worked out by other industries, and our first task here is to look about for suggestions.

The first step in improving honey markets does not lie in boosting the merits of honey by advertising schemes, but in the making of honey as fine a food as possible, avoiding all methods which make honey less desirable or which materially increase handling costs. Since at present honey is usually injured by the methods employed, it is timely to suggest studies which will eliminate the bad practices and which will give a better product. Since the physical state of honey affects its flavor in a remarkable degree, and since physical condition is so important in honey sales, honey physics should be the leading problem for a time. While beekeepers themselves do many things to honey which make it less desirable, honey packers are the greatest culprits, for these men are impressed with the necessity of doing things in a big way which from their very nature injure honeys. Of recent months a most wholesome interest on the part of packers in improving their methods has been evident, so there is real hope for the betterment of this branch of honey handling.

A study of the physical characteristics of honey requires specialized methods, perhaps more complicated than those necessary for a study of honey chemistry. We are dealing with a highly complex mixture of compounds, in liquid, solid and colloidal states, each having its effect on the physical phenomena of honey as a whole. The problems suggested are not simple ones and it will lead only to confusion if untrained men undertake them. Whenever a new line of work is suggested, there are some who always rush into them blindly, with resulting confusion in the literature. The problems suggested appear to promise so much improvement that they are of real importance to beekeeping, but slap dash methods will not bring advancement.

An outstanding difficulty in beekeeping work is that the investigator finds himself constantly confronted with new lines of scientific work which demand attack. Usually trained along some line of biological work, he is assumed to know how to do scientific work in chemistry, physics or biology, and some even have the temerity to attack economic problems. This is the greatest weakness in apicultural investigations in this country, and all that can be done is to make the best of a most difficult situation and get what help is possible.

CHAIRMAN: We will continue with the symposium and leave the questions until the end. We will hear from G. E. Marvin.

THE EFFECT OF TEMPERATURE ON HONEY IN STORAGE

By H. F. WILSON and G. E. MARVIN,[1] *Wisconsin Agricultural Experiment Station*

ABSTRACT

Honey may be stored at temperatures below 52° F. with apparent safety. Temperatures of 52–65° F. are more dangerous than higher or lower temperatures. A constant temperature of 80° F. is reasonably safe both as to changes in color and fermentation.

Honey is a very interesting sugar compound about which we know so little that it is difficult to discuss it in a thorough manner. Realizing the need for more definite information concerning honey, a specially equipped laboratory was established at the University of Wisconsin several years ago for the purpose of making certain studies on the physical and chemical properties of honey, as they might relate to storage between the time of removing it from the bees and distributing it to the consumer. Just how the idea should have developed that honey will keep indefinitely is hard to understand, in view of the samples which we have had an opportunity to observe in our work.

It is not impossible that honey could be preserved in its natural condition over a very long period of time, if properly stored. However, honey may be considered as a readily perishable product under average conditions, and those who have had an opportunity to observe samples of honey that have been held for a year or more recognize the fact that honey deteriorates very rapidly when improperly cared for. And among the bottlers and brokers, honey that is a year old is generally considered inferior to freshly extracted honey. This is true of much of the honey placed on the market, for the simple reason that most of our beekeepers are unaware that there are good and bad methods of storing honey

[1]Formerly with H. F. Wilson, at the University of Wisconsin, but now with the Bee Culture Laboratory, Washington, D. C.

after it has been extracted. We do not know of any data that demonstrates clearly how long honey may be preserved, but our own experiments show that if honey is stored at the proper temperature, it will not deteriorate to any appreciable extent over a period of more than a year.

There are three general conditions to be found in the deterioration of honey, any one of which is sufficient to lower the market grade of the product. These are, in line of importance—first, loss of flavor; second, spoilage by fermentation; and third color changes in which the color passes from a lighter to a darker grade. The proper handling of honey after it has been removed from the beehive and during its progress to the consumer is therefore a very important problem which has received very little study until in recent years.

Without knowing the reasons for deterioration in honey, or the manner in which to prevent harmful changes, our beekeepers have suffered losses of many hundreds of thousands of dollars over a period of years. The most important factor concerned in the deterioration of honey is temperature, although yeasts are constantly found associated with honey, and when the proper conditions appear, the yeasts grow and cause fermentation.

Honey is composed of invert sugars and water with slight traces of minerals, acids and proteins, the latter coming from pollen grains which find their way into the honey while it is being carried as nectar from the blossoms to the bee-hives. The invert sugars, composed principally of levulose and dextrose, make up about 75 or 80 percent of the volume of the various honeys, and the moisture content of these honeys varies from 14 to 25 percent, depending upon its ripeness.

If honey is not well ripened or is allowed to absorb moisture while stored in open tanks, fermentation is sure to occur when the temperature conditions are satisfactory. And even supposedly well-ripened honey is subject to fermentation as a result of the physical changes which occur during granulation after the honey is extracted and put in cans or jars.

All honeys which contain a high content of dextrose sugar, soon after being extracted, take on a crystalline form, and a superficial examination would lead one to believe that all of the honey had changed to crystals. But a more detailed examination would show that only the dextrose portion had formed crystals and that the levulose remains in a liquid form, interspersed between the crystals.

In all probability, in the formation of the crystals, the crystals give up moisture, and the moisture content of the remaining liquid becomes greater and thus prepares the way for the growth of yeasts when the suitable temperatures are present.

Investigations at this station show that the question of temperature is a very important one and that temperature control is quite important in the storage of honey. During the early spring of 1929, a series of four constant temperature chambers was constructed at the bee culture laboratory, and a series of 16 samples of honey taken at weekly periods from the beginning of the honey flow on June 26 to October 17 were placed in each of these chambers (a total of 16 samples being taken). The temperatures for the chambers were set respectively at 40°, 60°, 80° and 100° F. A chemical analysis, including moisture determinations and color grades, was made for each set of samples when they were extracted, and before they were placed in the temperature chambers. After having remained in the temperature chambers for a period of one year, one of each series of samples was removed, color tests were run and the moisture content was determined for the top and bottom of each sample in the series.

In every case where the honey had crystallized, the moisture content was found to be higher at the top of the jar than at the bottom. During the course of the work, frequent observations were made on the samples in each chamber, and it was noticed that the samples in the 40° chamber crystallized in a very short time, while those at high temperatures crystallized more slowly, and many of them never crystallized all the way through.

An examination of Figures 1 to 6 will show the approximate condition of the extracting frames at the time when the samples were taken, samples 11 to 13 not being included in this discussion, as all of the samples taken under these numbers are being held until the end of a two-year period.

The samples were taken from about the beginning of the honey flow, June 26, to October 17, 1929. In taking the samples, the extractor and honey tank were cleaned with boiling water and then thoroughly dried. The honey was strained through three thicknesses of cheesecloth, just as it ran from the extractor. Then it was bottled immediately. But, before using the bottles, they were thoroughly washed and sterilized. They were sealed immediately upon filling, labelled and put in the dark in constant temperature chambers, photographs being taken of representative combs at the time taken from a set of ten, the number used in taking each sample.

Sample Number 1. This sample was extracted June 26, 1929. Pl. 19, fig. 1 shows the approximate appearance of the combs at that time.

Sample Number 2. This sample was taken on July 3 from frames in which a small portion of the cells had just been capped as shown in Pl. 19, fig. 2.

Sample Number 3. This sample was extracted July 10, and at that time about ¼ of the cells were capped; the approximate condition of each frame is shown in Pl. 19, fig. 3.

Sample Number 4. This sample was extracted on July 17, and at that time the frames were about ⅔ capped, as shown in Pl. 19A, fig. 4.

Sample Number 5. This sample was extracted July 24, 1929, when about ¾ of the cells were capped, and the approximate condition of the frames from which this sample was taken is shown in Pl. 19A, fig. 5.

Sample Number 6. This sample was extracted July 31 when the combs were practically all capped, only a few cells being left uncapped along the bottom, as shown in Pl. 19A, fig. 6.

Sample Number 7. This sample was extracted on August 7 from combs that were completely capped; at the same time, the honey flow was still continuing; one set of samples was taken from a series of combs completely uncapped, as shown in Pl. 19, fig. 1.

Sample Number 9. This sample was extracted on August 14 from another series of uncapped combs with the same approximate appearance as Pl. 19, fig. 1.

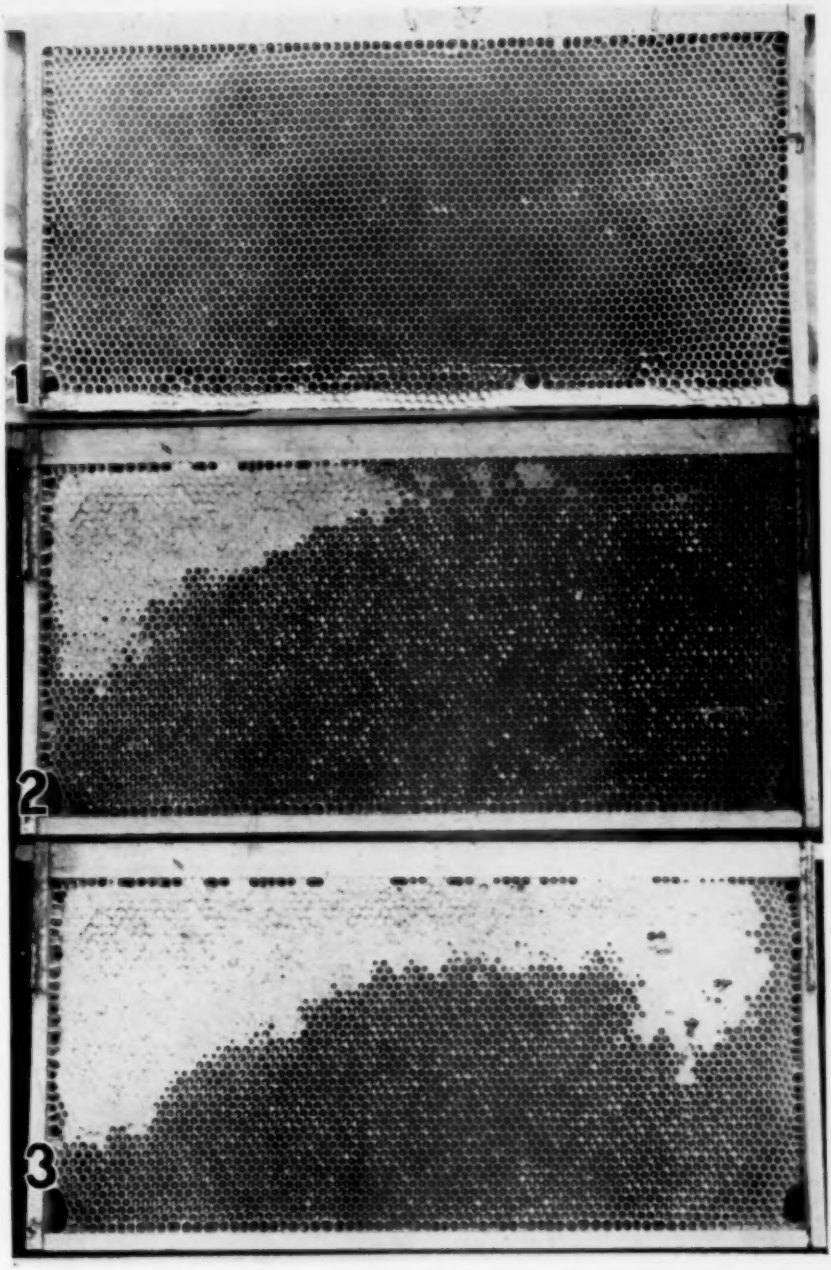
Sample Number 10. This sample was extracted from completely sealed combs, the approximate appearance being similar to the one shown in Pl. 19A, fig. 6.

Sample Number 15. This sample was extracted from a series of completely capped combs which had been removed from the hive on September 15, and stored in a dry, warm room until October 10, at which time it was extracted.

Sample Number 16. This sample was taken from another series of combs completely capped. They were removed from the bees on September 15 and stored in the extracting room with the sample taken on October 10. This sample, however, was not extracted until October 17.

Table Number 1 shows the color readings made on a U. S. Standard Grader. Unfortunately, an exact record was not made of the color readings at the time of extraction. However, exact color readings taken one year after the honey was placed in storage indicate that the colors of the honeys in the 40 and 60 degree chambers could not have undergone any appreciable change.

These readings being made only by eye comparison may be open to question. But in each case the color readings were taken for each sample without comparison of the others, and the fact that those from the 40 and 60 degree temperature chambers are exactly the same would indicate sufficient accuracy to make this method dependable for commercial color records. No difference could be noted between the samples in the



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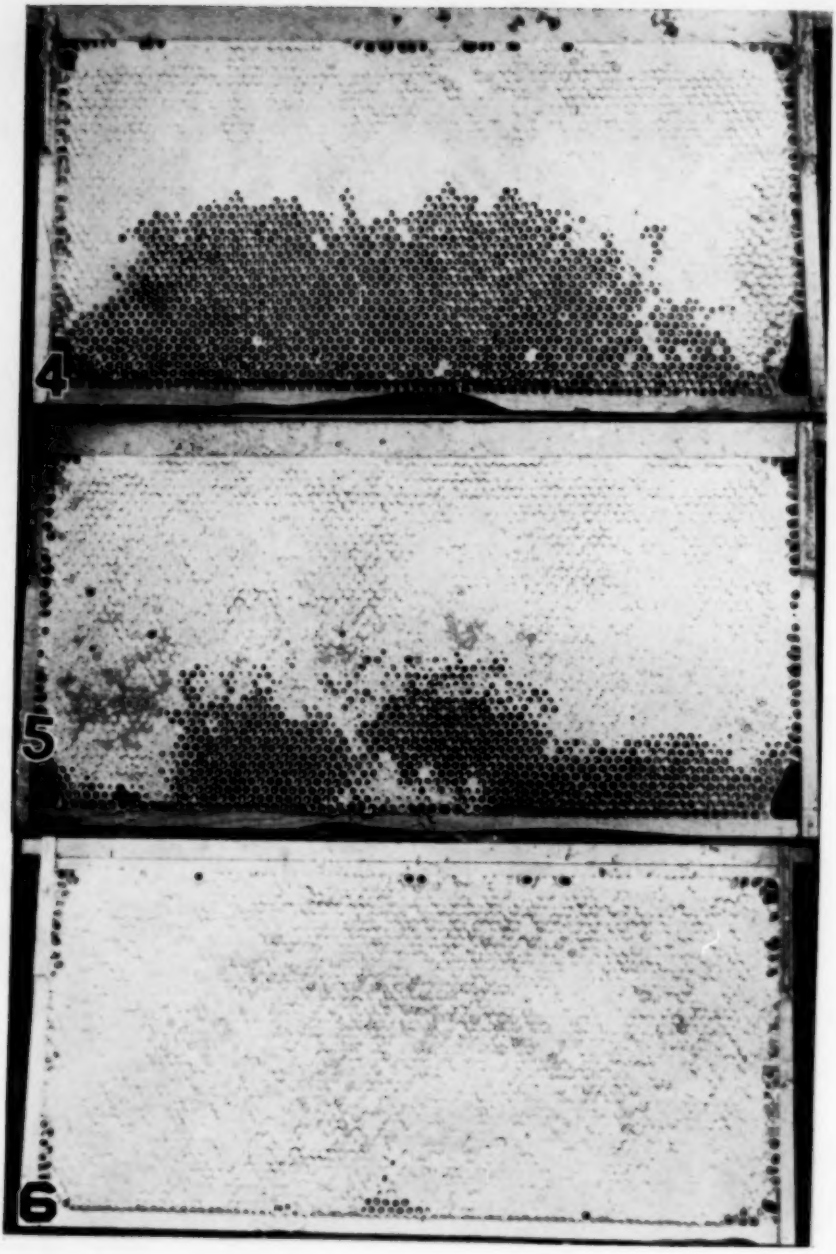
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TABLE 1. COLOR.

Sample	Temperature Chamber 40°	60°	80°	100°
1	.7cm Water White	.7cm Water White	1.4cm Extra White	4.4cm Extra light amber
2	.3cm Beyond Water White	.3cm Beyond Water White	.5cm Water White	3.2cm White
3	.3cm Beyond Water White	.3cm Beyond Water White	.5cm Water White	4.0cm Extra light Amber
4	.3cm Beyond Water White	.3cm Beyond Water White	.5cm Water White	4.8cm Extra light amber
5	.3cm Beyond Water White	.3cm Beyond Water White	.5cm Water White	3.6cm Extra light amber
6	.3cm Beyond Water White	.3cm Beyond Water White	.7cm Water White	4.9cm Extra light amber
7	.3cm Beyond Water White	.3cm Beyond Water White	.5cm Water White	5.6cm Light amber
8	0 Water White	0 Water White	.9cm Extra White	3.5cm Extra light amber
9	.1cm Water White	.1cm Water White	1.0cm Extra White	5.0cm Light amber
10	.2cm Water White	.2cm Water White	1.4cm Extra White	6.2cm Light amber
15	.7cm Water White	.7cm Water White	1.5cm Extra White	6.0cm Light amber
16	1.1cm Extra White	1.1cm Extra White	2.1cm Extra White	9.0cm Amber

40 and 60 degree chambers, and only a slight difference in the 80 degree chamber, showing that the honies in this chamber had not undergone color changes of any appreciable difference. However, when we come to the 100 degree chamber, a distinct difference was immediately perceptible to the eye, and this difference is very strongly indicated by the scale readings.

FLAVOR. Perhaps some accurate method may be later devised for comparisons in flavor, but we were compelled to depend entirely upon taste tests being made at two different times by both of the writers. (Table 2.)

TABLE 2. FLAVOR

	Temperature Chamber			
Sample	40	60	80	100
1.....	good	fermented	fermented	scorched flavor
2.....	good	fermented	good	scorched flavor
3.....	good	fermented	good	scorched flavor
4.....	excellent	fermented	off flavor	scorched flavor
5.....	excellent	good flavor	good flavor	scorched flavor
6.....	excellent	fermented	off flavor	scorched flavor
7.....	excellent	good flavor	good flavor	scorched flavor
8.....	excellent	fermented	good flavor	scorched flavor
9.....	excellent	fermented	good flavor	scorched flavor
10.....	excellent	badly fermented	good flavor	scorched flavor
15.....	excellent	excellent	good flavor	scorched flavor
16.....	excellent	off flavor	good flavor	scorched flavor

In the 40 degree chamber, the flavors seemed even better than when the honey was extracted, if such a comparison could be made after a year's lapse of time. Also, the tests of the flavors of the honey in the 40 degree chamber were made before any of the others, so that we were not influenced by the poor flavors of the remaining samples. No buyer or bottler could in any way object to the flavors of all these samples. In the 60 degree chamber, we find an entirely different condition. Only three samples compared at all with those in the 40 degree chamber. Of the 12 samples listed in this paper, two had retained a good flavor, and one an excellent flavor. Seven samples gave a distinct fermented taste, and one sample was off-flavor, although we were unable to decide whether or not it had a fermented taste. In the 80 degree chamber, we found still another condition. Only the first sample had fermented and all but three samples had retained a fair flavor.

A very peculiar condition found in this set of samples was the lack of fermentation in all but one sample, and the only conclusion that we could reach was that this temperature is too high for the growth of the yeasts which were found to ferment the samples in the 60 degree chamber. The flavor was markedly inferior to the samples in the 40 degree chamber. In the 100 degree chamber, the samples were all found to

TABLE 3. TEMPERATURE CHAMBER

Sample	40	60	80	100
1	Coarsely granulated; a little liquid on surface	Upper ¼ liquid. Lower coarsely granulated	Upper ¼ liquid. Lower coarsely granulated	Upper ⅔ liquid. Lower coarsely granulated
2	Coarsely granulated; a little liquid on surface	Coarsely granulated; liquid between crystals ½ inch liquid on top	Upper 1/5 liquid; rest coarsely granulated	⅜ inch coarse crystals on bottom; rest liquid
3	Fine granulation; dry	Smaller crystals than above —rest same	Crystals fine; ¼ inch liquid at top	⅔ coarse crystals; ⅓ liquid
4	Fine granulation and dry as in 3	Like 2	Coarse crystals from top to bottom; liquid in bet ween	¼ inch coarse crystals at bottom; rest liquid
5	Fine granulation and dry as in 3	Semisolid—coarse crystals	Same as 4	½ inch coarse crystals on bottom; rest liquid
6	Fine granulation and dry as in 3	Semisolid—coarse crystals	Completely granulated; very fine	⅓ coarsely granulated; ⅔ liquid
7	Fine granulation and dry as in 3	Very fine granulation	Same as 6	¼ finely granulated; ¾ liquid
8	Like 1 and 2	Medium coarse crystals; ⅙ liquid on top	Coarse crystals ⅛ in. liquid on surface	⅛ in. crystals on bottom; rest liquid
9	Like 1 and 2	½ coarse crystals; ½ liquid	¼ medium coarse crystals; rest liquid	Same as 8
10	Fine granulation and dry as in 3	Very fine granulation complete	Coarse granulation; ⅛ inch liquid on surface	¼ finely granulated; rest liquid
15	Very fine granulation creamy appearance	Same as 10	Medium coarse granulation complete	Lower ⅛ finely granulated; rest liquid
16	Very fine granulation creamy appearance	Same as 10	Same as 15	⅛ inch crystals on bottom; rest liquid

have a scorched flavor which would immediately reject them as number one commercial honeys. Because of this condition, further study of these samples has been discontinued.

Table number 3 includes a description of the samples at the time when they were opened after a year's storage. These descriptions are indicative only of the physical appearance of the samples at that time, and do not give a record of the actual differences in the size and amount of crystals formed.

GRANULATION. Careful observations on the time of granulation, the appearance and size of crystals formed were made from time to time. It was noted that there are several peculiarities in the crystallizing of honey, due to factors which are not at the present known. However, it could be definitely determined that less crystallization and larger crystals formed at high temperature, and small crystals, with a more complete crystallization, formed at the lowest temperature. Also, the condition of ripeness of honey seemed to be quite important, even in the coldest chamber. At 100° F. crystallization was very slow, and the amount of crystallization was small. When crystallization was formed immediately, the crystals were large, but at longer periods there seemed to be a separation and deposit of small crystals at the bottom.

At 80° F. apparent complete crystallization occurred only with the well ripened honeys, and even then the crystallization was not always complete. There was a wider variation in the form of crystals at this temperature than at any other.

At 60° F. the unripe samples did not crystallize completely, and in those samples where crystallization was complete, the crystals were large and flocculent in appearance, with interspaces of liquid honey.

At 40° F. all well ripened samples crystallized very finely in a solid mass. It was interesting to note that in these samples, the well ripened samples were dry at the top of the jar, while the unripe honeys or honeys that were extracted from honey on partially sealed combs were somewhat coarse in texture, and there was a certain amount of liquid at the top of the jar.

It is yet too early to form a definite opinion concerning the actual facts concerned with granulation of honey in these samples, but it is possible to see that there is a definite indication that the more rapidly honey granulates, the finer the crystals, and the more complete the crystallization. With rapid crystallization and fine crystals, the danger of fermentation is greatly reduced and may be completely eliminated.

It has been interesting to note that seeding honey with a few honey crystals brings more rapid crystallization, even of honey that has been once heated to prevent crystalization.

Conclusions

1.) Temperature plays a very important role in the deterioration of honey, and must be given very careful consideration in the storage of honey over a long period of time. Honey may be stored at temperatures below 52° F. with apparent safety, as no changes in color or flavor occur at temperatures below that point. Temperatures of 52 to 65 degrees are more dangerous than higher or lower temperatures, because these temperatures are favorable to yeast development and the danger of fermentation is exceedingly great.

At constant temperatures of 80° F. honey may be stored with a reasonable degree of safety, both as to changes in color and fermentation, although fermentation may occur and slight changes in color do occur. At temperatures higher than 80° F., and approaching 100 degrees, fermentation is not likely to occur to any appreciable extent, but the color changes may be detrimental. However, it should be noted that in one case where we have maintained the samples in a greenhouse over a period of one year and subject to changes in temperature through both the summer and winter periods, the samples in glass jars were lighter in color at the end of the period than when first placed in the greenhouse. It is entirely possible in this case that the bleaching qualities of sunlight may have a decided effect upon honey. And at the same time, the temperature is not sufficiently great over any period of time to cause carmelization.

Chairman: The next paper is by E. J. Dyce.

CRYSTALLIZATION OF HONEY

By E. J. Dyce, *Cornell University, Ithaca, New York*

Abstract

The quality of crystallized honey is highest when the crystals are small. The physical phenomena of crystal growth and the factors and method of controlling fine crystallization are discussed.

Crystallization of honey, commonly called granulation, is a physical phenomenon, as no chemical change is involved. The type of crystal formation is governed by its composition and by the physical phenomena to which it may be subjected. The usual constituents are seldom present in identical proportions in different honeys, and since physical influences constantly vary, there result differences in sizes and types of crystals. Quality of granulated honey, from the stand-

point of human taste, depends on size of crystals, and honey with large coarse crystallization is inferior to that with small crystals.

Chemical analyses show that the two principal sugars of honey are levulose and dextrose. Levulose usually predominates and occurs to an average amount of about 41%. It crystallizes with difficulty and is usually non-crystallizable. Dextrose is usually present to about 34%: it crystallizes readily and forms the solid phase of granulated honey. Sucrose and other constituents are usually present in small amounts, and it may be assumed that honey is physically a solution of sugars in water which behave like other similar mixed solutions.

In a study of crystal formation in honey, it then becomes desirable to study conditions under which crystals form in saturated solutions. Crystals form about nuclei and may be prevented from forming for long periods of time in chemically pure solutions. But when nuclei about which crystals may form are present, crystals grow according to the Noyes-Nernst formula:

$$V = \frac{\Delta}{1} S (C\text{-}L)$$

in which V = velocity of growth; Δ = diffusion coefficient; 1 = length of diffusion path; S = surface area of the disperse phase; C = concentration of solution; L = solubility of disperse phase of a given size and (C-L) = absolute saturation.

According to this formula, crystal growth in honey is directly influenced by the surface area of nuclei of crystal formation, by concentration of the solution, by the solubility of dextrose in relation to the presence of levulose, and by the diffusion coefficient, and inversely by the length of the diffusion path. Diffusion is of course affected by viscosity.

Jackson and Silsbee studied the interrelation of dextrose and levulose in water solution at different temperatures and show that the presence of levulose modifies the saturation point of dextrose. To cite a single example from their tables, at 30°C. a solution of dextrose and levulose is saturated with respect to dextrose when 34.85% of each sugar is present. Since 34% dextrose is an average for honeys, this means that at temperatures lower than 30°C. practically all honeys are supersaturated with respect to dextrose, so that crystal formation is possible unless prevented.

Most honeys show early crystal formation but certain honeys, such as sage and tupelo, may remain liquid for years. Chemical analyses show that the percentage of levulose in these honeys is unusually high.

Jackson and Silsbee in discussing this phenomenon offer "a possible empirical relation to predict granulation in honey," and state: "Since, at ordinary temperatures, one part of water holds in solution approximately one part of dextrose, the percentage of dextrose in the honey minus the percentage of water represents the per cent of supersaturated dextrose. The tendency to granulate would be roughly proportional to this quantity. This tendency is inversely proportional to some function of the levulose and we have selected arbitrarily the percentage of levulose itself. Thus

$$\text{Granulation tendency} = \frac{D—W}{L}$$

in which D, W, and L represent the percentage of dextrose, water, and levulose, respectively. The formula is very evidently a measure of instability."

When crystals form in honey, this occurs about nuclei, and these nuclei may be already existing dextrose hydrate crystals, colloidal particles, included solids or minute air bubbles. Such inclusions then serve to stimulate crystal formation, roughly in proportion to their amount and number.

The degree of concentration of honey is usually measured by specific gravity or the Beaumé hydrometer. Honeys giving a reading of 42° Beaumé or lower usually crystallize slowly, and if crystals form there is a tendency toward separation, especially in partially fermented honeys, leaving a liquid layer at the top. On the other hand, honeys showing a Beaumé reading of 44° or above may also crystallize slowly, since in such honeys the diffusion coefficient is low and a higher temperature is required to increase the rate of diffusion, thereby facilitating crystal growth.

Temperature has a direct influence on absolute saturation, as it affects the solubility of dextrose. Jackson and Silsbee give a table showing the approximate composition of invert sugar solutions saturated with respect to dextrose at various temperatures. Saturation is obtained at 0°C. with 50.8% invert sugar while at 50°C., 81.9% is required. The effect of temperature on viscosity of honey is well recognized. When honey is subjected to low temperatures, it becomes highly viscous and at room temperatures its mobility is greater. The effect of temperature on the disperse phase is equally well known. Honey prepared for the bottle trade is heated so that the disperse phase of dextrose hydrate crystals become completely dissolved and this sugar may remain in solution for a period of months.

The surface area of the disperse phase has a direct influence on the type of crystallization. If abundance of nuclei are present, the surface area is large and the dextrose in excess of saturation is rapidly drawn to these points of growth. Each crystal grows at approximately the same rate, and the dextrose in excess of saturation is depleted before the crystals become of objectionable size. If, on the other hand, only a few nuclei are present, the surface area of the disperse phase is small. The length of the diffusion path is then relatively great and the dextrose in excess of saturation will slowly become attached to these few points of crystal growth. The resulting foci of growth will naturally be large.

It is interesting to observe the crystal growth of dextrose under the microscope. At first fine needles are formed. These gradually change to flat, elongated plates with an area at the blunt end to which other crystals may become attached. From this place more plates are formed in all directions. The final crystal masses are star-shaped and are of considerable size, with numerous layers of plates radiating from the central crystallization focus. When rapid crystallization takes place, the dextrose hydrate crystals seldom attain growth beyond the stage of flat plates. Such plates are characteristic of fine granulation. Crystals become objectionably large only when the plates are in tiers and have usually commenced star formation.

The surface area of the disperse phase may be increased by the usual mechanical procedure of honey extraction. The small fragile crystals almost universally present in honey when extracted are subjected to considerable strain, and single crystals are often broken into fragments. The effect of such breakage is most evident when a honey pump is used. The pump also almost invariably causes many minute air bubbles to be incorporated which do not rise to the surface later and these form nuclei of crystal formation. The increased area of the dispersed particles is therefore in somewhat direct relation to the speed at which the pump operates and to the number of crystals originally present in the honey. The effect may be readily observed by removing a sample of honey from the extractor and comparing it with a sample that has been run through a pump. The latter will almost invariably crystallize more readily.

Crystals of dextrose hydrate may be introduced to honey accidentally or intentionally. A recent survey of Ontario honeys, with their detailed individual histories, serves to illustrate the accidental introduction of crystals. Honeys extracted from combs which were not cleaned of honey by the bees the previous fall crystallized rapidly; honeys extracted from combs which were cleaned, crystallized slowly.

Apparently the film of honey adhering to the cells of the extracting combs crystallized during winter. These combs, filled again by the bees and extracted the following season, contained enormous numbers of minute crystals which hasten crystallization.

Most honeys at ordinary temperatures have a relatively low diffusion coefficient. This is exemplified in a practical manner by placing two different honeys one on top of the other in a glass jar. Even at room temperature no noticeable diffusion occurs. The honey containing the most crystals will granulate prior to the other, and the line of demarkation becomes quite obvious.

Honeys of unusually high sugar concentration, crystallize slowly. The degree of rapidity is of course influenced by the surface area of the disperse phase, and by its solubility. Since temperature affects viscosity and solubility of crystals, it would also affect the diffusion coefficient. Therefore, for rapid crystallization, a temperature must be chosen which will affect viscosity in such a manner as to permit considerable diffusion without unduly increasing the solubility of the disperse phase. For average honeys this temperature obtained experimentally is about 57°F. Honeys with a high specific gravity require a slightly higher temperature; for samples of less concentration a slightly lower temperature is desirable. It is entirely erroneous to state, as is usually done in beekeeping literature, that fluctuating temperatures further honey granulation, or that granulation is most rapid at low temperatures.

The coefficient of diffusion and the surface area of the disperse phase have possibly the greatest practical influence on the length of the diffusion path in honeys. If diffusion is relatively high and the surface area of the disperse phase is great, the dextrose in excess of saturation will quickly attach itself to the foci of growth. If only a few crystals are present and the diffusion coefficient is low, large crystals of slow formation will result. Should the mobility of the honey be abnormally high, the disperse phase may settle to the bottom of the container, thereby lengthening the diffusion path and result in slow crystallization. This condition is most evident when the area of the disperse phase is small and when the honey is subjected to high temperatures.

It is common to observe a cloudy, flocculent curtain of crystals in liquid honey. This formation may be present in unheated honeys, but it occurs most frequently in samples which have been slightly heated. In such instances the area of the disperse phase is usually small and the coefficient of diffusion high. In other words the high viscosity of the solution does not permit the few crystals present to move freely. In such concentrated solutions diffusion is slow and the dextrose in excess of

saturation requires considerable time to attach itself to the crystal nuclei. Such slow forming crystals are invariably large in size.

The factors governing crystallization in honey are therefore analogous to other solutions. On briefly summarizing the Noyes-Nerst formula for crystal growth, we find that it is not set in motion until crystal nuclei are present. The formula, however, requires a disperse phase with a large surface area. To meet this requirement, abundance of small crystals in the form of finely granulated honey may be introduced. Since the length of the diffusion path should be reduced as much as possible for maximum rate of crystal growth, the disperse phase of crystals must be thoroughly distributed throughout the solution. The diffusion coefficient is usually unmodified except by temperature. It therefore becomes essential to select a temperature that will maintain super-saturation, giving abundant diffusion without reducing the solubility of the disperse phase.

These physical considerations are found to have a direct and practical bearing on the problem of preparing honeys for market. By first heating honey so that there is no further danger of fermentation and then by introducing a considerable percentage of fine dextrose hydrate crystals in granulated honey, a product can be made which shows uniformly fine crystallization within less than three days, the resulting product being of unusual merit from the standpoint of human taste. Accurate control of temperature at the time of introduction of the seed nuclei and later so as properly to control the rate of crystal growth is essential to success. This procedure has now been applied to over 75 honeys from different parts of Canada and the United States with uniformly excellent results, so that the methods appear to be practical for the honey trade. The process has the merit that it is economical of time and labor, so that it is hoped that it may prove valuable to the beekeeping industry. But it must be emphasized that the entire procedure rests on the basis of the physical characteristics of honeys, and these demand further study.

CHAIRMAN: The next paper will be presented by G. E. MARVIN.

SOME COMPARATIVE DATA ON MOISTURE DETERMINATION IN HONEY BY MEANS OF THE REFRACTOMETER AND THE VACUUM DRYING OVEN

By G. E. MARVIN and H. F. WILSON

During the course of our work with honey at the Wisconsin Bee Culture Laboratory, we have been in contact with the State Pure Food Laboratory, and the question as to whether or not better methods for moisture determination of honey could be worked out, has frequently arisen. Also, the question of whether or not the refractometer might be used commercially in judging the moisture content of honey has been discussed. Incidentally, we have tested several possible methods for mositure determination in honey, and because of the differences which they have shown, we believe that it is worthwhile to raise the question as to whether or not a more desirable method for determining the moisture in honey, than the sand-bath method now recommended by the Association of Agricultural Chemists, can be found. Just how much merit there may be in this suggestion, we are not ready to decide, but in the methods we have used, we have found more or less regular differences which indicate to us that the sand-bath method does not give an accurate determination of the moisture in honey samples.

As a point of discussion, we wish to call attention to the fact that when honey is dried in the sand-bath, the result is a very hard mass of sand and honey, in which it is difficult to remove the glass stirring rod commonly used. This would indicate that a thick film forms toward the outside of the mass which would naturally prevent a thorough drying out of the inside of the mixture. In using the refractometer and the sand-bath drying method, we have noticed a constant difference of approximately 2 to 2½ per cent. And in a comparison with glass plates, sections of blotter and asbestos, we have noticed a uniform difference for each method which would further indicate the desirability of a change in the present recommendations for the determination of moisture in honey.

In using small glass plates of uniform size, we have found that, with one exception, there was less moisture given off than with many of the other methods used. The explanation for this seems to be quite clear. When a film of honey is placed on the glass plate, it has only one surface for evaporation; this surface dries out more quickly than the interior of the sample and forms a thin film through which the moisture cannot escape unless the surface is disrupted or broken from time to time by means of a stirring rod. When sand is used, a slightly greater amount of moisture is given up by the samples, but undoubtedly the film which

forms on the outside of the sample affects the sample in somewhat the same way as on the glass plates.

When uniform pieces of blotter were used, a slightly greater amount of moisture was given up by the samples. In using uniform pieces of thin asbestos, we found that a still greater amount was given off, except in samples 10 and 11, shown in the accompanying table. Refractometer readings for the same samples were always higher, and the differences between sand and the refractometer are of sufficient uniformity to give a fairly accurate average.

It may be noted that in the use of different materials, there is a more or less uniform graduation between the glass plates, the sand, the blotters, the asbestos and the refractometer.

The two objections which might be brought up in opposition to the data presented are that there are not enough tests and that in consideration of the refractometer methods, the dextrin in the honey may have influenced these readings to such an extent that they are not accurate. But we intend to continue our tests, and we hope that a submission of this paper at this time may have the effect of developing further work in this connection which will bring about the establishment of an accurate and dependable method for determining the moisture content of honey.

COMPARISON OF SAND, GLASS PLATE, BLOTTER, ASBESTOS AND REFRACTOMETER AS MEANS FOR OBTAINING THE MOISTURE CONTENT OF HONEY

Sample	Sand	Glass Plate	Blotter	Asbestos	Refractometer
1	17.18	15.72	18.1	18.21	19.1
2	15.66	15.28	17.8	17.60	18.5
3	15.06	14.68	16.70	17.35	17.95
4	14.15	14.33	15.64	16.80	17.15
5	21.38	20.58	22.96	23.00	24.0
6	19.5	18.22	19.70	20.61	21.2
7	20.16	18.96	20.67	21.31	21.9
8	19.74	18.54	20.6	20.98	21.6
9	17.73	17.13	18.79	19.05	20.0
10	18.32	17.34	19.34	19.15	19.7
11	17.64	16.54	19.56	18.97	20.0

CHAIRMAN: The last paper on the symposium of honey by C. C. Gillette will be given by Dr. E. F. Phillips.

HONEY CATALASE

By CLAUDE C. GILLETTE, *Cornell University, Ithaca, New York*

ABSTRACT

The presence of catalase in honey has been confirmed. It is found that catalase is not produced by bees but that it originates in included pollen grains and arises from fermentation yeasts.

The occurrence of enzymes in honeys has recently attracted considerable attention, due chiefly to the use of an enzyme test in Germany for detecting purity of honeys. Auzinger in 1910 reported that catalase is present in honeys but made no effort to determine its origin. The present report gives the results of determinations of the effects of various temperatures on the activity of catalase and of determinations of comparative amounts in different honeys.

In the present work, the apparatus used by Heinicke for determinations of catalase in apple twigs was modified for use with honey, a two-arm reaction tube being used. The oxygen evolved was collected in a burette and measured in cubic centimeters from a given volume of honey in a given time. The pH and specific gravity of the various honeys were determined. It was found that a correction of the pH to neutrality did not increase the evolution of oxygen from honeys, so this was not commonly done.

In their work on the morphology and digestive activities of the alimentary canal of honeybees, Pavlovsky and Zarin report the absence of catalase in the honey stomach and in the large and small intestines of bees, except toward the close of the "hibernation" period when it occurs in the large intestine. Tests were made of sugar fed to bees in late October and no catalase was found in it.

Miss Paton reports the presence of catalase in several pollens. When the included pollen grains of honeys are concentrated by centrifuging, the catalase activity of the portion containing most pollen grains is much higher than that of the mixed honey. Pollen taken from combs also contains much catalase.

A 50% honey solution which is caused to ferment by the addition of yeast showed a higher catalase activity than did the original honey. The yeasts collected from the bottom of the vessel after fermentaton has progressed for a time showed about the same catalase activity as did other portions of the fermenting solution. It was found also that the catalase activity increases with time during which fermentation has proceeded.

In studying the effect of temperature on catalase in honey, 50% solutions were used. These were heated for various intervals of time and

to different temperatures. It is found that catalase is destroyed in honey quickly at 75° but that more time is required to destroy it at lower temperatures. Catalase activity is directly correlated with the degree of temperature to which the honey has been exposed.

A considerable number of different honeys were tested for their catalase activity and it is found that there is considerable variation. Catalase in 5 cc. of normal honeys releases from 0.1 to 0.7 cc. of gas in two hours at laboratory temperatures, while honeys that have been heated so as to destroy the enzymes does not cause the evolution of oxygen. The variation in the different honeys was not correlated with the amount of pollen present in the samples.

The tests made show that honey catalase does not come from the bees themselves but that it may have its origin either from included pollen grains or from yeasts that are present in honeys. Tests were not made to determine the catalase content of nectars, so this possible source of this enzymes is not yet determined.

CHAIRMAN: The previous papers on the Symposium of Honey are open for discussion.

Mr. Root will have a little to say regarding our trip to Medina tomorrow as guests of the A. I. Root Company.

E. R. ROOT: The roads are not safe at the present time for automobile traffic. An electric car can be chartered for $40.00.

CHAIRMAN: I will declare a five minute recess during which time Mr. E. J. Dyce will pass around the samples of honey showing the stages of crystallization.

CHAIRMAN: The next paper will be read by W. E. Dunham.

A COLONY OF BEES EXPOSED TO HIGH EXTERNAL TEMPERATURES

By W. E. DUNHAM, *Department of Zoology and Entomology, O. S. U.*

ABSTRACT

A colony of Italian bees was placed in a heat chamber where it was subjected to high temperatures to determine what effect if any, these temperatures had upon the hive temperatures. A discussion of the response of bees when high temperatures occur within the hive is also included in this paper.[1]

The purpose of this experiment was to determine the effect of high external temperatures on the temperatures within the hive. In order to

[1]The writer wishes to express his appreciation to Prof. W. M. Barrows for his helpful suggestions relating to this problem.

perform such an experiment it was necessary to construct a heat chamber in which the heat could be regulated at the desired temperature and at the same time have all other environmental factors the same as those of the check colony.

The heat chamber was constructed of beaver board material. The air space surrounding the hive was ten inches on the top, four inches on the bottom, four inches on the sides, and three inches on the back and at the front of the hive. An extension of the entrance was made which passed from the entrance of the hive thru the heat chamber and terminated out of doors, thus allowing normal flight activities. Heat was applied by means of a 100 watt electric light bulb which was suspended from the ceiling at the central point of the heat chamber. The temperature within the heat chamber could be regulated at any desired level by means of a thermostat which was connected to the electric light circuit.

During the first three days of the experiment no heat was applied around the experimental hive so the temperature surrounding this colony was the same as that surrounding the check colony. Beginning the morning of the fourth day the cover was placed over the heat chamber and heat was applied. The colony was subjected to normal temperatures during the first three days so that an accurate index of the normal hive temperatures could be ascertained. By surrounding the hive with much higher temperatures than were normal for the season, a study of the temperatures within the hive would reveal what influence high external temperatures have on the different regions of the hive.

At the close of the experimental period of 11 days the internal conditions of the colony were studied. An examination of the brood-nest revealed that the thermocouple junctions were located in two distinct brood-rearing areas, that is, those of the central brood area and those of the outer brood area.

Figure 41 gives a graphic picture of the average daily temperatures in the central brood area, outer brood area, heat chamber, and out door temperatures. Table 1 shows these same temperatures arranged numerically.

Before drawing any conclusions from the data gathered during this period of observation it was necessary to know about the conditions in the brood nest at the beginning and close of the experiment. When the experiment was started, the brood was irregularly scattered throughout the ten frames; and the queen, though appearing very vigorous had not been laying eggs rapidly except during the three days previous to the examination. That would mean that before any heat was applied the queen had been laying at least moderately well for six days. At the close

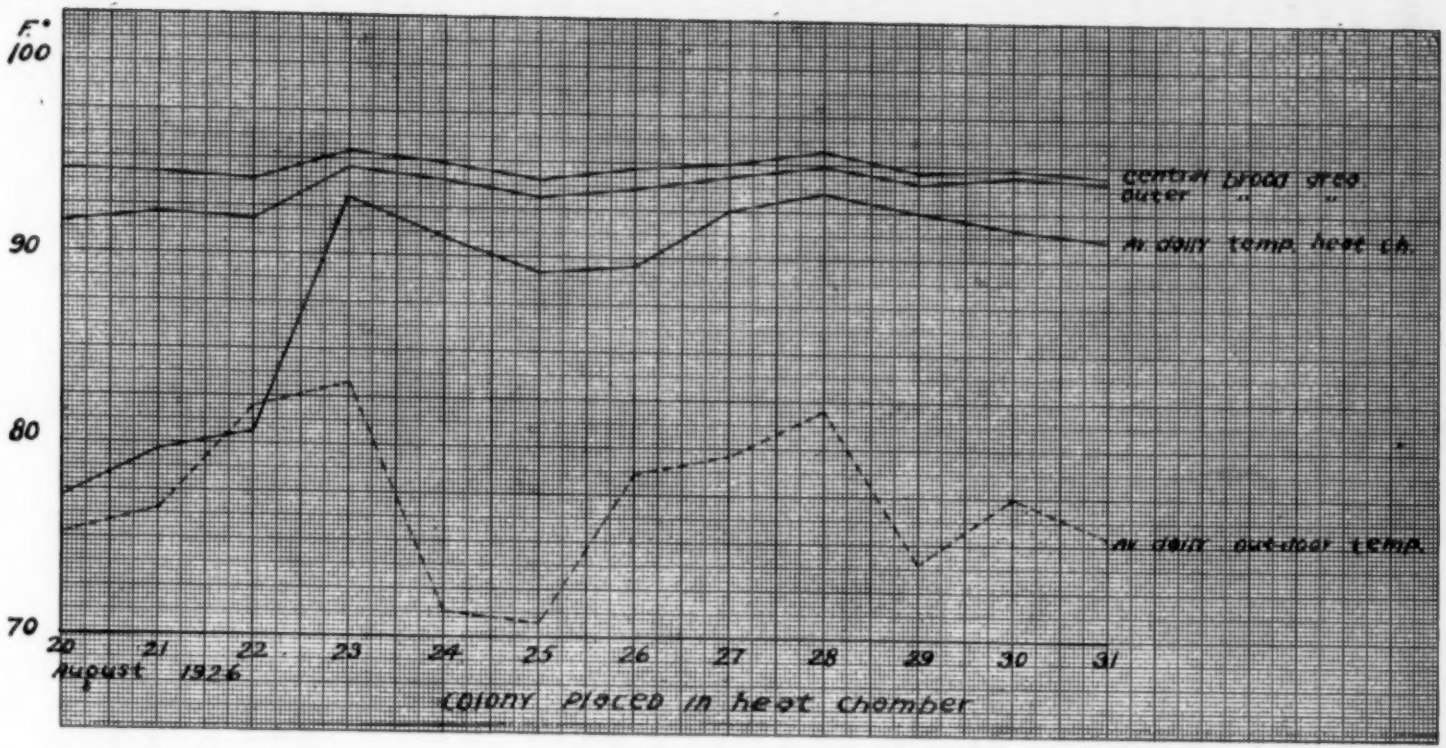
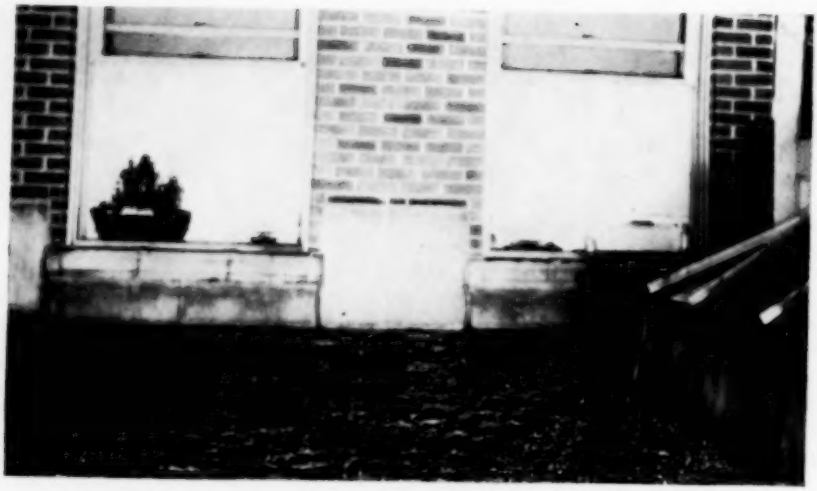


FIG. 41.—Graph showing conditions in heat chamber.

Plate 20



Comparative extent of the clustering of the bees at the entrances.

of the experiment the brood nest revealed that there had been practically no egg-laying during the days when heat had been applied.

Table 1 shows that during the last eight days of the experiment, the minimum temperature in the heat chamber was 89 degrees F. and the maximum 93.5 degrees F. These temperatures along with the temperatures designated as the daily average out door temperature curve represent the environmental temperatures to which the colony was subjected. The curve representing the temperatures in the central brood area during the same period shows a direct response to the rise or fall of these high environmental temperatures. In other words, when a colony is subjected to high external temperatures, the temperature in the central brood area reaches a point which is beyond the absolute control of the bees. However, within certain limits they can lower hive temperatures by fanning their wings and thus creating air currents, and by evaporating water which they have brought into the hive.

When comparing the temperatures of the outer brood area with the two curves representing the environmental temperatures it is seen, that external temperatures have a direct influence over the temperatures of this area.

A rather interesting feature of this experiment is that on the days when the environmental temperatures reached their highest points, August 23rd, and 28th, the highest temperatures in the central brood area and outer brood area also occurred.

Plate 20 shows the comparative extent of the clustering of bees on the outside of the entrances of the four colonies used in the temperature experiments. The colony at the right was the one which was subjected to low external temperatures, the two in the middle were the check colonies, while the one at the left was the colony subjected to high external temperatures. The clustering of bees outside the hive is brought about by high temperatures within the hive. The data gathered indicate that the coolest region in the brood-nest must reach 93.5 degrees F. in order to stimulate the bees to start clustering outside. The warmest region inside the hive at this same time may vary considerably depending on the height of external temperatures but always it will be at a higher level than 93.5 degrees F.

The general impression that some investigators give is that bees are able to prevent too high temperatures occurring within the hive by fanning their wings to produce air currents, along with evaporating water which has been brought into the hive, and by clustering outside the hive. The writer agrees that before temperatures occur which are so high as to stimulate the bees to cluster outside the hive, that the

cooling off of the hive is brought about by the bees by fanning their wings and by evaporating water. However, he believes that when temperatures become so high that these two methods are not effective that some of the individual bees leave the inside of the hive and go outside as a response against too intense heat, rather than a direct response toward correcting hive temperatures. Thus indirectly the bees lower the temperature inside the hive since having left the inside of the hive the air space there is increased and the two former methods of regulating the temperature become more effective. Also because there are fewer bees in the hive the amount of heat produced by bee activity would be less than before the clustering occurred.

TABLE 1. AVERAGE TEMPERATURE OVER A TWELVE DAY PERIOD WITHIN A COLONY SUBJECTED TO HIGH EXTERNAL TEMPERATURES.

Date	Ave. Temp. Central Brood Area	Av. Temp. Outer Brood Area	Av. Temp. Heat Chamber	Av. Temp. Outdoor
8/20/26.....	94.2°F.	91.5°F.	77.2°F.	75.2°F.
8/21/26.....	94.1	92.1	79.6	76.6
8/22/26.....	93.8	91.9	80.7	82
8/23/26.....	95.3	94.7	92.9	83.3
8/24/26.....	94.9	94.1	91.1	71.4
8/25/26.....	94.7	93.9	89	70.6
8/26/26.....	94.5	93.5	89.4	76.5
8/27/26.....	94.7	94.1	92.4	79.5
8/28/26.....	95.6	94.9	93.5	82
8/29/26.....	94.4	93.9	92.4	73.9
8/30/26.....	94.6	94.3	91.6	77.5
8/31/26.....	94.3	94.2	91.	75.3

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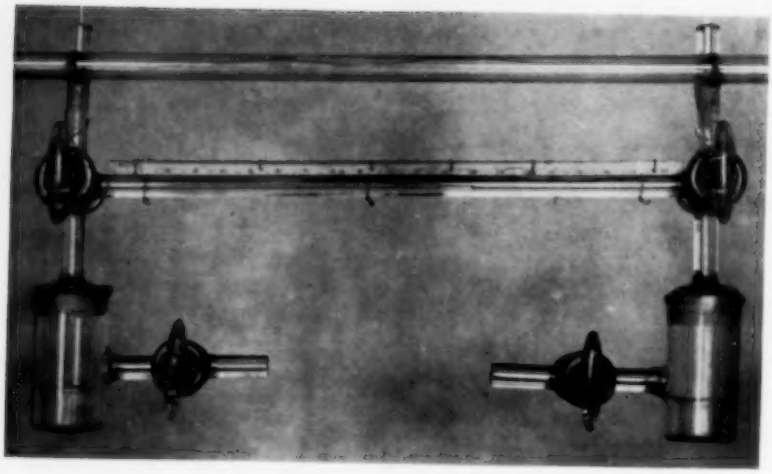

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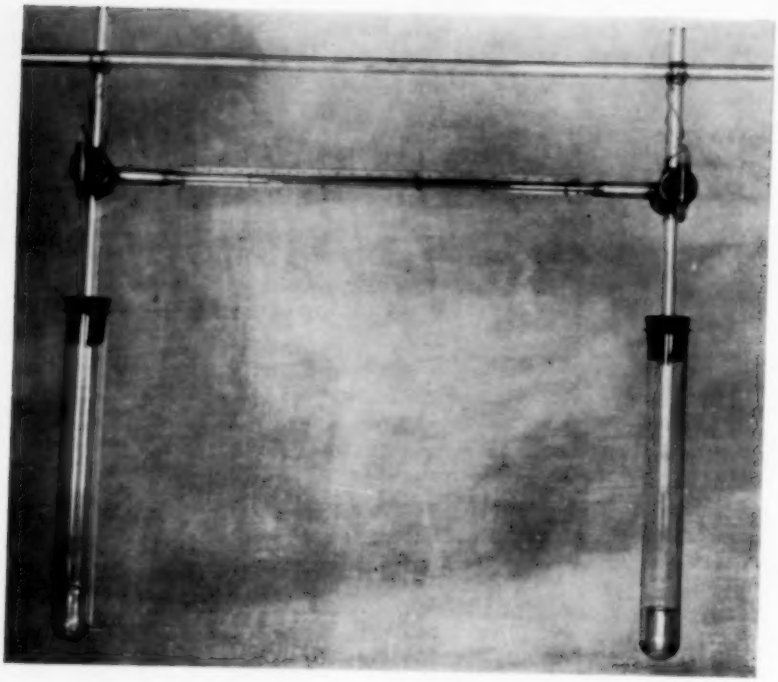

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Thunberg microrespirometer modified.

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CHAIRMAN: The next paper will be read by M. D. Farrar.

METABOLISM OF THE ADULT HONEY BEE

By M. D. FARRAR

ABSTRACT

Measurements have been made to determine the influence of temperature on the rate of metabolism of the adult honey bee. The response to temperature is negative at 0°; slightly variable at 14° to 26° and greatly variable at higher temperatures. Respiratory quotients for all temperatures indicate that the diet of the adult honey bee is composed largely of carbohydrate.

The greater part of this study has been carried on in a microrespirometer modified after Thunberg 1905 and Trendelenburg 1909. The instrument is volumetric in nature and consists of two small respiratory chambers of equal capacity connected together thru stop-cocks by a fine capillary tube. In the capillary is placed a drop of oil and any change in the capacity of either chamber is read on a scale along the length of the capillary tube by observing the movement of the oil drop.

In this paper only the oxygen consumption and the carbon dioxide output have been measured. In the case of the adult honey bee little attention need be given to metabolic exchanges other than those two gases. The diet of the adult bee, in so far as is now known, is almost exclusively made up of pure carbohydrates. Honey makes up the greater part of the bee's diet. Bees have been fed on diets containing only the pure monosaccharides, dextrose of levulose, and they appear to live equally well on these as they do on honey.

INSTRUMENTS. The Thunberg microrespirometer used in these experiments has had several modifications to Thunberg's original design. Plate 21, figs. 1, 2.)

The capillary tube of his instrument, instead of being straight, was bent slightly downward in the center. Recent experiments have shown the straight capillary tube to be equally satisfactory. Fundamentally, however, the apparatus is little different from the original design. The first use of the apparatus was for measuring the minute gas exchange between algae and a small sea-anemone. Later works have adapted its use to other fields requiring the micro-measurement of gases: Trendelenberg for small invertebrates, Krogh and Van der Hyde for insects, Hopkins for tadpoles and muscle tissues, and Fenn for nerve tissue.

MEASUREMENT OF CARBON-DIOXIDE. The carbon-dioxide[1] eliminated is measured by an indirect method. In these experiments, dilute sulphuric acid was used in the respiratory chambers instead of the potassium hydroxide. The sulphuric acid absorbs neither the oxygen nor the carbon-dioxide. Since the gases exchanged were equal at equal pressure, the difference between the oxygen consumption and the carbon-dioxide elimination was read by the movement of the oil bubble. Knowing the difference between the two gases, and the amount of oxygen consumption from previous experiments, the carbon-dioxide elimination was determined.

MEASUREMENT OF OXYGEN. An equal amount of potassium hydroxide was placed in the bottom of each respiratory chamber. The glass supports for the organisms were then lowered into each chamber. The desired number of bees were confined in one chamber and the other chamber was left empty of bees. Both chambers were attached to the instrument proper and the connections made absolutely tight. From experiment to experiment the opposite chambers were used for the bees in order that any possible error of capacity might be off-set. The entire instrument (except for the tips of the side arms) was then submerged in the water bath for one hour before closing the chambers to atmospheric pressure. After one hour the stop-cocks were turned to connect the chambers with the capillary tube and the movement of the oil drop recorded. In this case the carbon-dioxide given off was absorbed in the potassium hydroxide. The slight reduction in pressure within the chambers, altho computable, was considered of slight importance.

[1](In making readings on the carbon-dioxide elimination of bees, it was found impossible to make both oxygen and carbon-dioxide measurements on the same bees due to the rapid rate of starvation for isolated honey bees. Calculations on carbon-dioxide are therefore relative only, and not absolute. The uniformity of results using large averages would indicate that the respiratory quotient was fairly accurate for adult honey bees.)

METABOLISM AS INFLUENCED BY TEMPERATURE RANGE. The graph of data for all temperatures is given in Figure 42, 4. This curve is complete only in so far as the experiments are concerned and can be assumed to be true only for the conditions under which the experiments were carried out. A true metabolic curve will be established only by additional experiments for all temperatures throughout the yearly cycle.

REACTION OF BEES TO EXPERIMENTAL CONDITIONS. Bees reacted in a different manner to every set of experimental conditions. A graphical representation of these reactions is given in Figure 42, 5. It will be noticed that temperature as related to activity has an important bearing on the life of the bee during the experiments. The higher temperatures seemed to shorten the lives of the bees proportionally to the amount of food they carried at the time they entered into the experiment. The arrows show the apparent duration of life as indicated by the results secured at the respective temperatures.

LOW TEMPERATURES. The aim of the experiments with low temperatures was to place the bees under such conditions that their metabolism would become basal or below basal. At 14°C. or higher the factor of activity is involved bringing in a great source of error in results. There may be a temperature between 0.3°C. and 14°C. at which a basal condition might be approached, but such a temperature was not determined in these experiments. At the temperature of 0.3° Centigrade there was no noticeable activity of the bees after the first three minutes of exposure. The bees had been taken from the winter cluster that had a temperature of not less than 14° Centigrade and at 0.3° Centigrade their metabolism decreased hourly to that shown in Table 1 and Figure 42, 3.

TABLE 1 GIVES THE AVERAGE RESULTS OF GAS EXCHANGES FOR ELEVEN OXYGEN AND FOUR CARBON DIOXIDE EXPERIMENTS AT 0.3° CENTIGRADE—760 MM.

Hour of Reading	Oxygen	Carbon Dioxide	Respiratory Quotient
2	29.64	28.56	0.962
3	17.49	16.41	0.939
4	12.76	11.68	0.915
5	10.35	9.27	0.905
6	8.29	7.21	0.870
7	8.20	7.12	0.868
8	7.91	6.83	0.863
9	7.90	6.82	0.863
10	7.74	6.66	0.853

HIGHER TEMPERATURES. The results for bees at temperatures where they were active is summarized in Table 2. A marked correlation is shown between activity and metabolism. The oxygen consumption for bees on a kilogram basis is shown in Table 3.

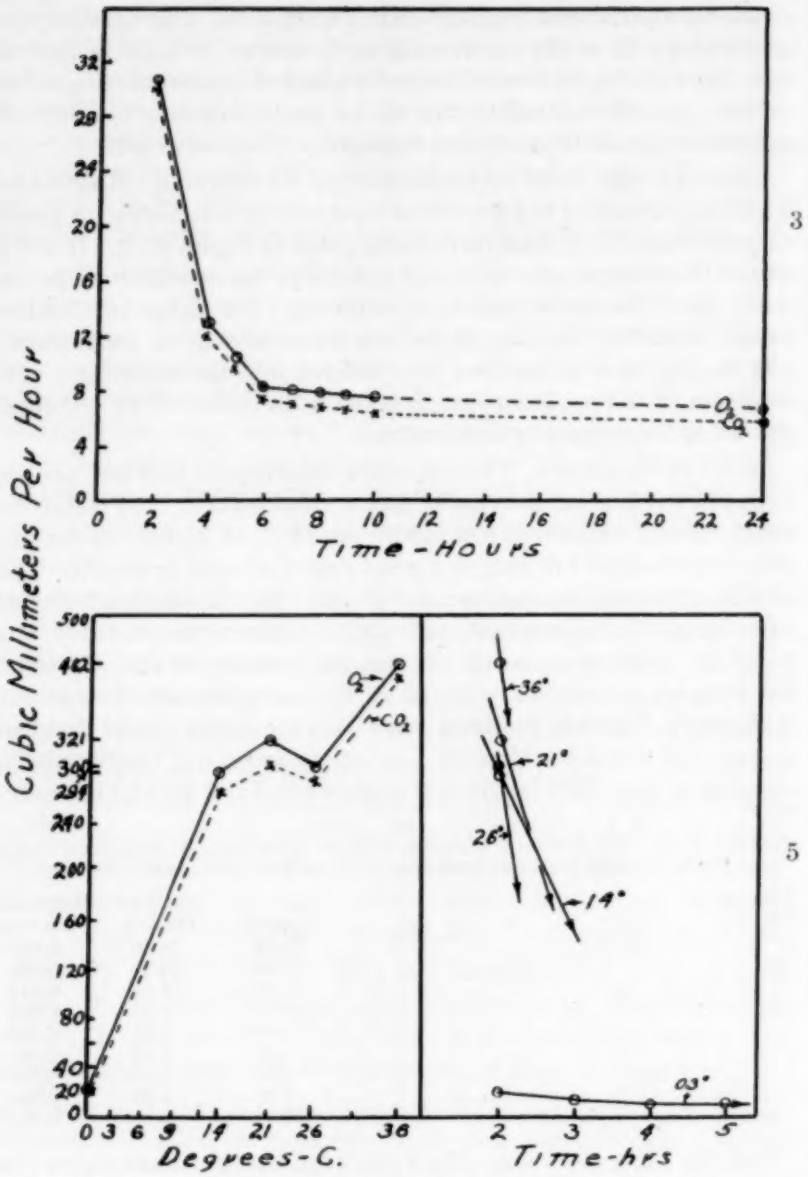

FIG. 42.—Metabolism and temperature.

TABLE 2.

Activity	Temperature	No. of Tests	No. of Bees	Gas Exchange in Cubic Millimeters per Bee per Hour: Oxygen Range	Average Consumption Oxygen	Average Output Carbon Dioxide	Average Respiratory Quotient
None.....	0.3	9	29	——	29.6	28.5	0.962
Quiet.....	14.0	16	96	94–573	293.8	276.6	0.942
Quiet.....	21.0	15	90	248–427	321.0	283.8	0.884
Quiet.....	26.0	14	58	214–464	299.5	283.3	0.947
Quiet.....	34.0	10	20	403–724	578.0	485.8	0.840
Active.....	34.0	5	10	1074–2120	1718.8	1590.0	0.924
Quiet*.....	34.0	7	16	118–278	223.2	——	——
Quiet.....	36.0	4	16	277–662	462.8	445.7	0.942

*Newly emerged bees.

TABLE 3. LITERS OF OXYGEN USED PER KILOGRAM OF BEES (MINIMUM FLYING WEIGHT OF 82 MILLIGRAMS) FOR THE SECOND HOUR AFTER EXPOSURE AT THE RESPECTIVE TEMPERATURES.

Temperature	Cu. mm. per hr. Oxygen	Liters Oxygen	Activity
0.3° C.....	29.64	0.36	None
14.0°C.....	265.2	3.23	Quiet
21.0°C.....	308.0	3.76	"
26.0°C.....	299.9	3.67	"
34.0°C.....	578.0	7.05	"
36.0°C.....	462.8	5.64	"
34.0°C.....	1718.8	20.96	Active

SUMMARY

At the temperature of 0.3° Centigrade, the adult honey bees become inactive almost immediately and their metabolic rate decreased rapidly for about six hours, after which the decrease continued very gradually. The bees recovered, when returned to room temperature, after having been subjected to 0.3° Centigrade for a period of twenty-four hours or longer, existing during this time at a very low rate of metabolism.

Since there was no apparent activity at 0.3°C., and seemingly normal activity (for experimental conditions) at 14.0°C., the great increase in the metabolic rate over that range in temperature indicates that activity is a determining factor in the rate of body metabolism.

Evidently the activity within the hive at 14.0°C. is considerably less than that for bees under experimental conditions at that temperature. If the metabolic rate of bees within the hive were as great as that of bees under these experimental conditions, they could not exist over winter on the supply of food stored in the hive. Under normal conditions (winter) there must be a specially organized metabolic rate, thru cluster formation, in order to conserve the food supply of the colony.

Experiments conducted at the temperatures of 14.0°C., 21.0°C., and 26.0°C. indicate that over this range of temperature adult honey bees are but little influenced by the temperature variations.

The adult honey bees were unusually active at 34.0°C. and at 36.0°C. This excessive activity caused death in a very short time and the length of life under these experimental conditions was proportional to the amount of honey each bee carried. Experiments indicate that adult honey bee metabolism is greatly variable at these temperatures.

The respiratory quotients for all temperatures show that the diet of the adult honey bee is composed mainly of carbohydrates.

The removal of adult bees from their normal surroundings seemed to create an abnormal amount of activity measurable directly in the rate of metabolism.

The rate of metabolism of adult honey bees is influenced to some extent by the temperature.

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CHAIRMAN: The next paper is by E. L. Sechrist.

ECONOMIC APICULTURE

By E. L. SECHRIST, *Associate Apiculturist, Bureau of Entomology, U. S. Department of Agriculture*

An English beekeeper who says that he has a dozen "stocks" and is "keen on the craft" asks: "Are there no villages in the United States where one can see a garden with a row of perhaps only six hives, and where swarms still hang on trees or on gooseberry bushes as in England? Are there no places where the same trials which affect us in England also affect beekeepers in the United States, so that we can speak on terms of intimacy?"

"People in the United States," he goes on to say, "seem to buy sections by the tens of thousands, comb foundation by the hundred weight; different kinds of engines are recommended for running extractors, or motor lorries for carting honey—everything, in fact, on so large a scale that we are stricken dumb. Are there no ordinary beekeepers who keep just six or a dozen stocks, as we do, and who are thankful if they get a few hundred pounds of honey and sometimes less?"

His observation is a just one. We do have but few such small apiculturists who keep bees scientifically, as a hobby and because they like the honey the bees produce, although we do have many people who own six or a dozen hives of bees, people who seldom are apiculturists—they merely let the bees keep themselves or else acquire disease and die—much to the detriment of their neighbor beekeepers who do try to deserve the name of "bee-masters."

It would be well for beekeeping in the United States if we had many beekeepers who operate on a small scale and who, like this Englishman, were "keen on the craft." It is just because there are so many such beekeepers in Europe that so much scientific work on bees is done there by so many people. In the United States the commercial beekeeper finds it necessary to devote all his time to honey production or to rearing queens in a wholesale fashion and seldom has time to devote to the scientific side of the work, even if he had the inclination. He leaves that work to "The Government"—State or Federal—or to the Agricultural Colleges.

It is these enthusiastic small owners of bees who are responsible for the extensive general use of honey in Europe. They talk bees and honey at every opportunity. They use much honey themselves and cause other people to want it. They thus create a market for a great deal more honey than they themselves can produce. We believe that much of our marketing problem in the United States would be solved if we had numerous

back-lot beekeepers who, like the Englishman, kept six or a dozen hives, and kept them well. Besides that, many of these people, being professional men with some spare time for a hobby, would do much excellent scientific work on their pets.

These well distributed colonies in the hands of enthusiasts are kept in good condition, and are thus of much importance to growers of fruit who must have bees near their orchards to insure good pollination.

Although we must recognize the excellent work in apiculture which has been done by some commercial beekeepers and by others who have made beekeeping a hobby, apiculture in the United States has, in too large a measure, been in the hands of unscientific owners of bees, just because our floral and seasonal conditions are such that it has been comparatively easy for one with little real knowledge of apiculture, and less than that of the economics involved, to make a fair success of commercial beekeeping.

But that time has passed, and we are feeling the need of accurate information as to what methods of apiary management are most successful and why they have succeeded. We have no such mass of detailed information on the economic value of different operations and plans of beekeeping work as has been gathered for nearly all other industries in the United States and are, therefore, handicapped in appraising scientifically the economic value of any apicultural operation.

While it is true that many valuable methods of apiary management have been devised, much of this information cannot be used effectively, or even disseminated, because we are often at a loss to know which operations are basic, and therefore of value, and which are merely incidental and without value, because they are not necessary and basic factors. There was a time when we thought bees swarmed just because there were too many bees in the hive; now we know that the real cause is more complex and that improper distribution of the bees in the hive is a large factor, the number of bees being only one of the causes of swarming.

For many reasons, such as the lack of knowledge about honey on the part of the consuming public, and the intense competition between honeys of different quality but equally good, as well as the competition in the price asked by the producer, the apiculturist has been forced to accept a lower income than he has a reasonable right to expect. Proper grading of honey is a large factor in good marketing and, therefore, U. S. Grades for honey have been established. It has now become necessary, if apiculture is to continue to develop in harmony with the increasing use of honey and the demands by orchardists and farmers for bees for pollination of fruits and seeds, to determine accurately those operations and processes in api-

culture which are economically effective and to discourage and discard ineffective and wasteful methods.

As a means to that end, the U. S. Bee Culture Laboratory inaugurated in 1928 a study of apicultural management in Montana, Wyoming, Idaho, Colorado and Utah, these states being large producers of high grade white honey from alfalfa and sweet clover. This study has now been extended to include the white clover region, work being now under way in representative sections of New York, Ohio, Michigan, Wisconsin, Minnesota, and Iowa. One preliminary report has been issued, besides the individual yearly reports sent to each cooperating beekeeper, and other reports are in preparation.

The results of this first study have been such that a general survey of the major beekeeping regions of the United States is now demanded and is under consideration.

The work which has already been done in these limited regions would not have been possible had not the Bee Culture Laboratory received the willing and effective cooperation of the U. S. Bureau of Agricultural Economics, as well as of the entomological, economic, and extension service divisions of the several states. Nor will it be possible to make a survey of the whole United States within any such time as the circumstances demand, without further assistance from the same divisions in the remaining states.

It is true that economic success in beekeeping depends largely upon seasonal conditions and the nectar secreting flora of the locality; that is, upon the natural honeyflow. However, our records show that one man may, in any locality, year after year, have a low financial return, or may even work at a loss, while another man, in the same locality and under the same conditions, may make a good profit. The difference between these results must necessarily be attributed to a difference in the apiary management, due to the use of a different system of beekeeping or to the personal characteristics of the apiculturist.

A striking instance in point was seen this year, where two men were giving practically all their time to apiary work with their 300 colonies of bees. These bees were not storing honey, but were swarming excessively. The owners wanted to know why the bees would not go up into the supers and store honey. The answer was very simple. The owners had mismanaged their bees under the conditions they had to meet, and had upset the normal broodrearing of the colony in their endeavor to give the bees room. The next visit, a few miles away, in the same kind of floral conditions, was to two men who were operating, in addition to 800 colonies of bees, a farm, a dairy, and a chicken ranch. All these industries

were prospering. The bees were too busy storing honey to do any swarming. These last two men worked no harder than the first two, but they had managed their bees so that the storing impulse was dominant and the swarming impulse suppressed.

This difference in management may be found not only in the beekeeping operations which are followed but in the effectiveness with which the operator uses his mechanical equipment and his own labor, or hired labor. Many beekeepers are not prepared, either by habit of thought or by training, to study these various factors efficiently or to make correct decisions thereon, and the consequence is that too many of them have gone on, blunderingly, building up their apiaries from the original half dozen hives, continuing methods and practices that should be discarded, with the consequence that we find one beekeeper able to handle a thousand colonies of bees as easily and even more effectively than another man can handle half that number.

When a man has ten colonies of bees it is no serious loss if he spends hours hunting up each and every queenbee, not because there is any necessity for it, but just because he wants to know that she is in the hive and to see what a fine queen she is. But when a man operates a thousand colonies he has little time to devote to the appearance of the queens. To find that a queen is laying as many eggs as she should and placing them properly is all he needs to know for the good of the colony, and one minute for examination will tell him that, while it might take him 30 minutes to find the queen herself. Often, indeed, the expert beekeeper needs only a glance at the bees working from the entrance to the hive to know that all is well or that something is wrong and must have attention. Diagnosis of conditions from the entrance is often quite possible and, if a beekeeper has his colonies in proper condition, a visit of half an hour by a good beekeeper to an apiary may tell him more and be more effective for financial success than a half day spent by one who is not a "bee master."

Because of the numerous and complex factors involved in the production of nectar in the blossoms of plants, such as seasonal rainfall, temperature, and storms, as well as soil conditions, insect pests, plant diseases, and methods of agriculture, apiary management must be varied as greatly as the varying conditions encountered in the widely divergent natural and agricultural regions of our country. What is excellent management in one locality or in one season may be totally inefficient in another locality or another season.

For instance, in certain localities the main honeyflow begins late enough in the season to permit a colony to be divided into two parts in the spring

and both parts built up into good honey producing colonies by the time of the late honeyflow, thus making it possible to secure double the crop of honey and removing the trouble from swarming that would, in all probability, occur if the colonies were not divided. If such a plan was followed in a region having an early honeyflow the result would be the loss of the entire crop.

It becomes necessary, therefore, in any study of beekeeping management and practice to consider all those factors which, although they are in great measure outside the control of the beekeeper himself, are largely responsible for the size and quality of the crop of honey he secures. It is also exceedingly difficult in such a study to separate the effects of such natural causes from the immediate effects of the method of management used by the beekeeper and from his personal efficiency in carrying out that system, such as his personal ability to work and his skill in managing hired labor. It is also made more difficult to determine cause and effect because of the fact that any method of beekeeping management which has not been planned and studied scientifically usually includes some processes and practices which are not only useless, but are harmful through slowing up the work of the bees or of the operator.

Any method of beekeeping management, to be successful, must therefore be adapted (1) to the man who is to use it, (2) to the vagaries of the season, (3) to the exact locality in which it is to be used, and, (4) what is by no means least, to the characteristics of the behavior of the interesting insect which produces the honey, because its behavior is conditioned by the effect of the first three items—the man, the season, and the locality—upon its own hereditary instincts and activities.

The problems which confront the Englishman with his row of six hives in his garden, where swarms hang on the trees or gooseberry bushes are evidently quite different from, although even more interesting than, those which must be solved by the commercial beekeeper. The problem is still more difficult for the investigator who would determine what causes produce certain effects in ten thousand different localities having ten thousand variations in soil, climate, pests, and seasonal conditions, and among ten thousand beekeepers, each one of whom uses a system of management which varies in some degree or in some detail from that used by his neighbor.

CHAIRMAN: I will now give the address by the chairman.
(Copy not supplied).

CHAIRMAN: The next paper by C. L. Farrar will be read by M. D. Farrar.

THE EVALUATION OF BEES FOR POLLINATION

By C. L. FARRAR, *Massachusetts Agricultural College*

ABSTRACT

Data obtained during two seasons' observations at Amherst, Massachusetts, on the number of bees furnished during fruit bloom by overwintered colonies, package bees, and nuclei indicate a pronounced advantage in using properly overwintered colonies.

New England beekeeping has not developed along commercial lines due to the fact that there is no single honey plant sufficiently widespread to give a dependable surplus. The number of colonies found here is, therefore, limited, apiaries are scattered, and methods of practice lack uniformity. The region is capable of supporting many more colonies than are at present cared for, and there is evidence that where strong colonies are maintained a creditable surplus of honey can be produced. Probable honey production alone, however, is not sufficient stimulus for the expansion of New England beekeeping.

For the past three to four seasons active interest by commercial orchardists in the pollination of their orchards has created a demand for bees beyond the present beekeeping facilities in this area. The majority of available colonies have been rented for the period of fruit bloom. One Massachusetts county in 1930 imported approximately 2,500 pounds of package bees from one shipper.

Beekeepers are divided in their opinions regarding the capacity of the "colony-unit" for honey production or the pollination of blossoms. Too often statements are based entirely upon opinion while other differences may be accounted for by the lack of a uniform standard for measuring colony efficiency. Many orchardists are now convinced that they must include bees in their program, and there is a marked tendency towards an even greater use of bees. Considerable emphasis has been placed upon the necessity for designing a "colony-unit" that the fruit grower can use without a knowledge of bees and with a minimum of handling. Upon this development rests the question of whether to stimulate practical beekeeping or to depend upon package bees.

For the honey producer, the colony-yield is a fair index of its efficiency. The work of the honey bee is only one of several important factors determining the set of fruit; also, a colony's flight can not be restricted to a definite block of trees. Hence the orchard yield can not be accepted as the standard of measure for the colony's efficiency in pollination. Pollination is purely an accidental result of the bees' activity on the blossom while collecting food. This fact must be accepted, yet

the degree of pollination should be proportional to the number of bees visiting the blossoms. Their effectiveness can be insured only by the proper grouping of compatible varieties.

Interpretations of data herein reported are made upon the assumption that the colony-unit furnishing the greatest number of field bees per minute will provide visits to the greatest number of blossoms and, therefore, accomplish the greatest results in pollination. Exact determination of the number of bees in each colony was made during the first week in May by a system of weighing. Because of the impossibility of making a direct count of the bees entering or leaving a strong colony, a plan of trapping the bees for a definite time interval was employed. A box four inches square with a length equal to the width of the entrance was provided with an opening which matched the full entrance; the side resting on the approach to the entrance was scarcely more than one-sixteenth of an inch in thickness, which provided the least possible abnormal obstruction to the bees leaving the hive. The box was painted white similar to the hives. The bees leave the hive in a normal manner and, being attracted to the light through the glass, seldom re-enter. By placing the box on the entrance for a two-minute interval and then determining the number of bees caught, the flying rate per minute can be calculated. Returning field bees will not enter the box in normal flight no matter how near its opening approximates the normal position of the hive entrance. The records were therefore made only on the bees leaving the hive. Enough boxes were used to allow counts to be made on a series of colonies at approximately the same time, when factors of light, temperature, humidity, wind, etc., were common to all the colonies under observation.

Colony Units Compared. In 1929 the average strength of overwintered colonies on May 5 was 5 pounds of bees (maximum, 7 lbs., 3 oz.; minimum, 1 lb., 9 oz.) with an average potential increase in strength in 12 days of approximately 50 per cent, due to emerging brood although some of the original bees would have died. Apple bloom extended from May 11 until May 20, during which period weather factors were decidedly variable. Three-frame nuclei wrapped in tar paper were set out for observation as representing one form of "minimum-attention colonies" recommended to the fruit growers. Three pounds of package bees were also wrapped in tar paper and allowed to "fly" through a queen excluder in order to prevent absconding. Each of these packages tried to swarm several times before they started combs and began brood-rearing.

In 1930 the average strength of overwintered colonies on May 1 was 5 pounds and 14 ounces of bees (maximum, 9 lbs., 1 oz.; minimum, 2 lbs., 8 oz.) with sealed brood, giving a potential increase of about 50 per cent. Apple buds developed from the pre-pink stage to full bloom within 24 to 36 hours and lasted from May 5 to 12. The results in 1929 emphasized a possible advantage of stronger packages so that two-, three-, and five-pound packages were compared, both when wrapped in paper and when installed in hives. The writer felt that the efficiency of the package could be improved by heavy feeding in order to stimulate immediate comb building, thus permitting brood-rearing to begin. It had been suggested that the odor from the tar paper might possibly have caused the bees to attempt to abscond from the packages the first season. Most of the packages were, therefore, wrapped with heavy building paper. The season advanced so rapidly that the packages could not be provided in suitable condition for checking some of the problems involved. Peaches, plums, cherries and apples all secreted so much nectar that strong colonies averaged a 5-pound gain for 11 days and no signs of absconding were noticed in the packages whether fed or wrapped with tar paper.

1929. The summation of data must be made only on colonies with records taken at the same time because of the influence of time of day, weather factors, and the food supply in the field. The results are, therefore, tabulated according to the period taken. Since the records in 1929 were taken at least 12 days after the colonies' strengths were determined, their strength at the fruit bloom period was estimated from the potential strength on May 5 (total bees plus sealed brood).

May 17, 4:30 to 5:10 p.m. Temp. 73° F. Bees entering per min. Free flight.
3 3-frame nuclei averaged 21 bees per min. (max., 28; min., 16)
3 3-lb. packages averaged 47 bees per min. (max. 53; min., 41)
May 18, 9:45 to 10:00 a.m. Temp. 67° F. Bees leaving per min.
3 7¾-lb. colonies averaged 67 bees per min. (max., 72; min., 49)
2 3-frame nuclei averaged 11 bees per min. (max., 15; min., 7.5)
May 18, 10 to 11 a.m. Temp. 68° F. Bees leaving per min.
5 8-lb. colonies averaged 133 bees per min. (max., 155; min., 93.5)
1 3-lb. colony averaged 44 bees per min.
1 3-frame nucleus averaged 13.5 bees per min.
1 3-lb. package averaged 7 bees per min.
May 18, 3 to 4:30 p.m. Temp. 70° F. Bees leaving per min.
12 8-lb. colonies averaged 114 bees per min. (max., 170; min., 59)
4 4¼-lb. colonies averaged 58 bees per min. (max., 70; min. 53)
3 3-frame nuclei averaged 6 bees per min. (max., 9; min., 3)
3 3-lb. packages averaged 4.2 bees per min. (max. 9; min. 0)*
*One swarming.

The flying rate in the above observation on normal colonies is almost proportional to the colony strength, with a slight advantage in favor of the stronger colonies. Even the weaker of these were so much supe-

rior to the packages and nuclei under the conditions handled that there seems to be little inducement for using packages when normal colonies can be obtained. Except for the first period, the nuclei showed higher flying rates than the packages. This situation is misleading, for after the package bees started brood-rearing they flew at a much greater rate than did the nuclei. The nuclei made little or no gain in bees following the fruit bloom period. In this weakened condition one of these developed European foulbrood by the middle of June (the only case of this disease occurring in the yard during the past four years).

1930. The flying rates of three packages installed on foundation April 21 and fed continually as much sugar syrup as they would take were compared with six overwintered colonies on May 7, 11 a. m.; temperature 90°F.; relative humidity 50%. (Package strengths April 21, colonies estimated from potential strength May 1.)

1 package, 3 lbs., 12 oz., averaged 15 bees per minute.
*1 package, 5 lbs., 4 oz., averaged 12.5 bees per minute.
1 package, 5 lbs., 0 oz., averaged 48.5 bees per minute.
2 colonies 3 lbs., 14 oz., averaged 64.5 bees per minute.
4 colonies 7 lbs., 4 oz., averaged 128.3 bees per minute.

*Queen superseded May 4.

The four colonies with 1.87 times as many bees as two of medium strength furnished just twice as many bees per minute. The normal 5-pound package had a flying rate 3.2 times that of the normal 3-pound package but only .75 times that of the medium and .38 times that of the strong colonies. The number of combs drawn by these packages was proportional to the size of their clusters. The supersedure of the queen is extremely detrimental to the working efficiency of the colony as indicated by the 5-pound package in which the queen was superseded.

Average flying rates for eight 2-minute intervals for each colony of the following series were taken between May 7 and 12. The colony strengths were estimated from May 1 records. The eight strong colonies were working freely in three 10-frame hive bodies; the three medium colonies in two 10-frame hive bodies.

8 colonies, 9 lbs., averaged 132.3 bees per minute (max., 225; min., 71)
3 colonies, 5 lbs., 4 oz., averaged 81.6 bees per minute (max., 140; min. 25)

The flying rates of these two groups were practically proportional to their strengths. Five of the eight stronger colonies on which flight records were taken stored four times as much honey between May 1 and June 10 as did the three medium strength colonies. An important point in explaining this relationship is the fact that the percentage of brood to the total number of bees in the colony bears an inverse relation to its strength. The flying force may bring in food proportional

to the colony strength, but where brood-rearing is proportionally high the food consumption bears this same relationship.

The rapid development of the orchards into full bloom made it impossible to obtain packages in time for comparison with colonies. Ten packages containing from 2 to 6 pounds of bees (no allowance for shrinkage) were filled from local colonies on May 7, fed and kept in the bee cellar until the evening of May 9, when they were heavily fed, wrapped in paper, and set out for flight. There was a noticeable return of bees to their original colonies so that their strengths had to be estimated from their condition when dismantled on May 24. Packages with 3 to 4 pounds of bees averaged 17.6 bees per minute on May 10 and 12, which was about one-sixth the efficiency of medium, and one-tenth that of strong colonies.

The following packages were planned for fruit bloom but arrived too late. They were installed on drawn combs May 13. This series gives an average of seven 2-minute flight intervals for each group taken May 23 and 24 when the temperature ranged between 79 to 95 degrees F. The absence of nectar is indicated by the fact that a full strength colony on scales decreased 8 ounces on both days.

1 2-lb. package averaged 33.5 bees per minute
(Cluster strengthened by drifting, larger than 3 lbs.)
1 2-lb. package averaged 8 bees per minute
(Cluster weakened by drifting)
2 3-lb. packages averaged 21 bees per minute
(Package average:—25 and 17)
4 5-lb. packages averaged 42 bees per minute
(Package average:—54.5; 44.3; 35.2; 33.5)
2 5-lb. (est.) colonies averaged 62 bees per minute
1 7½-lb. (est.) colony averaged 82.4 bees per minute
1 10-lb. (est). colony averaged 107.8 bees per minute

Two- and 3-pound packages here averaged 19.2 per cent as efficient as the strongest colony, while the 5-pound packages averaged 39 per cent.

Summary and Conclusions

During 1929 under normal seasonal conditions, strong overwintered colonies furnished approximately eight to twenty times as many field bees per minute as did either 3-pound packages or 3-frame nuclei when the bees were allowed to fly from their shipping package. During 1930 when conditions were abnormally favorable for bee activity, normal overwintered colonies showed a decided advantage over 5-pound packages which in turn were superior to smaller packages. Where local colonies can not be maintained or rented, it seems advisable to secure strong packages at least a week in advance of the ex-

pected fruit bloom. These should be installed in hives, preferably on drawn combs, and fed freely in order to insure an immediate establishment of the brood nest. Normal overwintered colonies requiring from 10 to 30 combs will easily be worth from $5 to $15 during the pollination period in competition with packages at their present cost.

Dr. E. F. PHILLIPS. We are all anxious to see the figures published as presented in the paper. In Wayne County, N. Y., there are 36,000 acres of apples alone. The inspection service found 639 apiaries, of these 155 contained only one colony. There are probably not enough colonies in N. Y., of the desired strength to supply the growers. Something else must be done.

Mr. R. L. WEBSTER. In Washington bees are carried 150 miles to be used for pollination purposes. In the fruit section of Wenachee very few bees are kept since there is very little pasture for them. 24,000 cars of fruit are shipped annually from this section.

HYDROGEN-ION CONCENTRATION OF SOILS AND ITS RELATION TO THE IMPORTANCE OF WHITE CLOVER AS HONEY PLANT[1]

By E. OERTEL, *Assistant Apiculturist.*
Southern States Bee Culture Field Station, Baton Rouge, Louisiana

ABSTRACT

A preliminary study of the pH values of Louisiana alluvial and upland soils indicates that there is not a close relationship between soil acidity and white clover growth. The pH value of some upland soils where white clover makes a poor growth is 6.5 while alluvial soils, where white clover grows luxuriantly, have a pH value of 6.5 to 6.7. Many southern soils have a higher pH value than do soils in the socalled "white clover region" of Northeastern United States, but white clover is not generally regarded as a honey plant in the South. Some other factor other than available calcium in the soil is probably important in limiting the nectar secretion of white clover.

For a number of years it has been customary to credit certain areas in various northern and northeastern States as being particularly well adapted to the production of white clover honey. Although white clover (*Trifolium repens* L.) grows abundantly over most of the northeastern part of the United States, it is generally believed that white clover secretes nectar best when growing in a soil high in calcium. Eastern Wisconsin is nearly always referred to as a good location for the

[1]This is a contribution from the Southern States Field Station of the Division of Bee Culture, Bureau of Entomology, maintained cooperatively by the U. S. Department of Agriculture and Louisiana State University, and located at Baton Rouge, Louisiana.

production of white clover honey because in that district the soils are largely derived from weathered glacial till or underlying limestone, and consequently are believed to be high in lime. Although white clover grows quite generally throughout New York State, it is claimed that one of the reasons for its importance as a honey plant in the northern part of the State is the difference in the lime content of the soil. Southern New York soils are regarded as acid, that is, low in calcium, while those soils in northern New York are believed to be high in calcium. It has frequently been said that the acid soils in the Southern States prevent white clover from being an important honey plant in that area.

One of the problems of the Southern States Field Station of the Division of Bee Culture, Bureau of Entomology, is the study of Southern honey plants. In an attempt to determine whether the distribution and nectar secretion of certain plants are correlated with the hydrogen-ion concentration of the soils, a number of soil samples have been collected and studied. These soil samples were taken from the first six to nine inches of surface soil by means of a soil auger. Several borings from ten to fifteen feet apart were made for each sample, and the soil was then well-mixed in order to eliminate as much as possible the chance that one boring alone might not be representative of the soil in that location.

"The pH value of a soil" is the measurement of the hydrogen-ion concentration of that soil. The symbol "pH" refers to a logarithmic term with which we need not be concerned. At pH 7 the soil solution is regarded as neutral, but as the alkalinity increases, pH values go above 7, and as the acidity increases, the pH values go below 7. A pH value of from 6.5 to 7.0 is generally regarded as nearly neutral. The pH value is a measure of the intensity factor of acidity, not a measurement of the quantity of an acid present. The colorimetric method is used at the Station in the soil tests. Dr. A. H. Myer of the Experiment Station, Louisiana State College of Agriculture, rendered assistance in the laboratory tests.

The pH value of soil on the so called "bluff land" near Baton Rouge is 6.5. White clover is not widely distributed on this soil, and it generally makes only a short growth where it is found. Alluvial soil south of Baton Rouge, near the Mississippi River, has a pH value of from 6.5 to 6.7. Clover grows well on this soil. In Avoyelles Parish, where white clover grows luxuriantly and is grown for seed, the pH value of a soil sample is 6.9 or nearly neutral. The sandy soils of the hilly section of northern Louisiana, where white clover is seldom found, have a pH of 5.8. In the vicinity of Gainesville, Florida, where the surface soil is extremely sandy, the pH value varies from 5.2–6.3. White clover is not found

growing on this soil. In the Black Belt of Texas the soils are calcareous (high in lime), according to Fraps and Carlyle (1). They say in part, "The highly-basic calcareous soils occur chiefly in the Black Waxy Prairie Belt, though there are also areas around McMullen and Bee Counties. These soils tend to be slightly alkaline in reaction. They have a high buffer capacity. These soils are not likely to become acid, or to need lime for legumes." Other portions of Texas are either moderately acid or highly acid, but white clover is not regarded as an important honey plant in the Black Belt of Texas.

According to Pierre and Parker (6), who investigated the pH value of a number of Alabama soils, the pH values range from 4.46 to 7.88. These last soils surely must contain a large amount of calcium, but white clover is not generally given as an important honey plant in Alabama. Tidmore and Parker (9) in a study of Alabama soils give a pH value for Greenville sandy loam of 5.28 to 6.48, and for Norfolk sandy loam of 5.21 to 6.15. Other soils have a pH ranging from 4.82 to 5.88. The first two soil types make up a large part of the Alabama soils. Soil types found in northern Alabama, and which were derived from limestone, are not included in the study just mentioned. Neither Lovell (4) nor Pellett (5) give white clover as a honey plant for any portion of Alabama, but Hawkins (2) does give it as an important source. The following statement is made in the soil survey for Houston County, Alabama: "Practically all of the well-drained upland soils are either neutral or slightly acid in character." Houston County borders upon the Gulf of Mexico. Marengo County, in southwestern Alabama, has about 9 per cent of its area in Houston and Sumter clays, both of which are calcareous. Greene County, in western Alabama, has over 20 per cent of its area made up of soils containing much calcareous material. Much of this land is in pasture, so it would seem that white clover might grow here and secrete nectar if calcium is so highly essential to secretion. Until comparative pH tests have been made of soils in the Northern States and soils in the Southern States, can we continue to explain that clover does not secrete nectar in the South because "the soils are acid"?

Two soils from the Southern States have the highest pH value.

A part of Mississippi is covered by a mantle of loess, a wind-formed soil type that is extremely common in Iowa. No information was available concerning the pH value of this soil, in either Mississippi or Iowa. However, there are areas in central and east central Mississippi which are underlain by chalk or other calcareous materials, and in places this is within two feet of the surface. It is probably true that part of the calcium originally present has been removed from the surface soil by leaching, much as it has been in soils in the white clover belt.

Pierre and Worley (7) give the following table of some soils studied by them:

Soil No.	Soil Type	Location	pH Value	pH of limed soil After 6 Months
670	Black clay loam	Illinois	5.20	6.60
671	Gray silt loam	Illinois	4.50	6.35
672	Cecil sandy loam	South Carolina	5.80	6.63
673	Cecil silt loam	Mississippi	6.48	6.83
674	Cecil clay loam	Alabama	6.00	6.80
675	Norfolk sandy loam	Alabama	5.65	6.53
676	Colby silt loam	Wisconsin	5.60	6.75
678	Cecil clay loam	Alabama	5.50	6.68
679	Miami silt loam	Wisconsin	5.80	6.68
680	Greenville fine sandy loam	Alabama	5.40	6.58
	Average for all soils			6.64

In a private communication to the writer, E. Truog, well-known Professor of Soils at the University of Wisconsin, says: "The soils of the eastern part of Wisconsin vary greatly in reaction. Usually the surface soil is acid and ranges from a pH of 5 to 6. The subsoil at a depth of 30 to 40 inches is usually neutral or alkaline due to the underlying limestone." He says further that non-acid surface soils also exist scattered through the area.

Calumet County in Wisconsin, underlain by the Niagara Escarpment, has three extensive soil types which make up 62 per cent of the total area. (See Soil Survey of Calumet County, Wisconsin, No. 16, Series 1925.) These soils are all underlain by limestone rock and the surface soil is derived largely from this material. According to the soil survey the surface soil and the upper part of the subsoil show a slight to medium degree of acidity. The lower part of the subsoil contains much calcareous material, and it is alkaline in reaction. Liming of the soil is recommended for most parts of Calumet County when alfalfa and the clovers are to be successfully grown.

The conditions described in the previous two paragraphs seem to indicate that in eastern Wisconsin, where white clover is a major honey plant, the soils are generally acid, in fact more acid than a number of soils in certain Southern States where white clover is either not found or where it is considered of little value as a honey plant.

In northeastern Ohio the lighter colored soils are quite acid, their pH values ranging from 4.75 to 5.50, but the black soils are not acid. In northwestern Ohio, according to information obtained from E. P. Reed, Specialist in Soils at Ohio State University, "70 per cent of all these soils show some degree of acidity." Many of the soils in other parts of Ohio are either acid or slightly acid, but much white clover honey is produced in the State.

The soils of New York State vary considerably in their pH values. North of the Mohawk River the soils have a pH value of about 5; in Southern New York the soils have a pH of from 4.5 to 5; but in the St. Lawrence Valley and the Champlain Valley, where the soils are of lacustrine origin, the pH value is from 7.5 to 8. Only a small percentage of the total soils in the State are still high in lime. Liming is recommended on many soils, even when they have been derived from limestone, in order that clovers and alfalfa may make a good growth.

Powers (8) has found that a maximum development of alfalfa plants occurs at a pH of 5.6 to 6.5, and of alsike clover at a pH of 5.5 to 6.0. Even if we assume that nectar secretion is correlated with maximum plant development we can not say that alfalfa requires a soil high in calcium, since a pH of from 5.6 to 6.5 is acid, and alsike clover is even less exacting apparently. Probably we still do not know the interrelationships necessary in the soil to create optimum plant growth and nectar secretion. From the scattered data presented in this paper it would seem that we can not say that white clover secretes nectar best on soils high in lime, or in a certain section of the country where it has been commonly, and apparently incorrectly, assumed that the soils in that section are high in calcium merely because they have been derived from underlying limestone rock or from glacial till rich in limestone. The soil may be high in calcium, but this calcium may be combined with silicates and be of no value for plant growth. Possibly the root system of white clover reaches more calcareous material in the white clover region of the North than it does in the South, but there are no data available concerning this point. The amount of calcium in the soil may have an influence upon the secretion of nectar by the white clover plant, but this may be indirect. Calcium may improve the physical condition of the soil, increase the available sulfates, or have some other influence. Some investigators state that acid soils are likely to be low in available nitrates, soluble sulfates, and organic matter. Quite frequently increasing soil acidity is associated with finer texture, poorer aeration, and poorer internal drainage. Internal drainage of a soil may be more important than the external drainage. Many of the soils in the South with a high pH value are called heavy soils. They are hard to work and are poorly drained. Possibly the system of agriculture which has been generally practiced in the South has been instrumental in keeping the acreage of white clover at a minimum.

It is true that white clover is a major honey plant in parts of the United States, but it also seems true that in certain areas where the soils have been supposed to be high in calcium they are really deficient

in it and may even be called acid. There are extensive areas in the South where the soil is nearly neutral, and some areas are alkaline. It seems to be advisable that we look further for an explanation of the copious secretion of nectar by white clover in favored localities. Possibly meteorological conditions have a greater influence upon nectar secretion than has generally been recognized. Institutions in the Northern States giving work in Apiculture might well spend some time in trying to learn what meteorological conditions are correlated with the nectar secretion of their major honey plants. Kenoyer's (3) work should be considered only as a beginning. All manner of soils and soil conditions might also be studied in connection with nectar secretion.

Summary

A study of the soils in different parts of the Southern States in comparison with soils in the "White clover region" of the Northern States indicates that the pH values of soils may not be a reliable index to the value of white clover as a honey plant. There are large areas in the South where the soils are neutral or only slightly acid, but white clover is not considered to be an important southern honey plant, notwithstanding the fact that calcareous soils are supposed to be highly suitable for the growth of white clover and the secretion of nectar. Probably climatic conditions and the system of agriculture in the South are important limiting factors in the distribution of white clover and consequently its value as a honey plant.

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CHAIRMAN. Mr. E. R. Root will present the next paper.

E. R. ROOT. Recent Developments Regarding Bees in Apple Orchards.

(Copy not received)

E. R. ROOT. Mr. Geo. S. Demuth, editor of Gleanings, will now talk to you about corn sugar.

GEO. S. DEMUTH. Commercial Beekeeping began in 1906 with the passage of the pure food law. Ever since certain interests have been trying to break it down. The corn sugar interests have just made a big breach in this law. The pure foods law makes illegal interstate shipment of foods injurious to the health. It also makes a declaration of the contents on the label necessary. The newspapers announce a ruling by the secretary of Agriculture, Mr. Hyde, which makes the placing of corn sugar in foods legal without a declaration on the label with the exception of honey. The object of the corn sugar people is not the financial gain from the increased sale of sugar but to break down the pure foods law. It is now up to the beekeepers to work through the states and uphold as far as possible the pure foods laws in the states.

CHAIRMAN. The next paper is by E. J. Anderson.

PROBLEMS AND ANSWERS IN EXTENSION BEEKEEPING

By E. J. ANDERSON, *State College, Pa.*

After passing through another season of extension work in beekeeping the speaker feels that the extension problems are just a little clearer than they have been before. Those engaged in other fields often overlook or underestimate the tasks placed before an extension worker or do not appreciate his duties in relation to their field of work. It is his task to interpret and present before the farmer in an attractive manner the results found by those engaged in experiment station work. The extension worker is often under a handicap because of lack of experimental evidence on certain subjects for his particular state. It is up to the extension specialist of any state to determine the problems of his beekeepers. He must translate and present to the beekeepers new or advanced methods of beekeeping in such a manner that they will be adopted by a large number of beekeepers. The extension specialist can not present to his beekeepers all the new ideas which look promising. Some of them may be too advanced others may not be adaptable to the conditions in his state. Perhaps the greatest of the problems is to

present advanced steps on management in such a manner that the older and larger beekeepers will accept them.

The beekeeping of Pennsylvania has progressed fairly rapidly in certain sections but not in others. In the east and southeastern sections beekeeping is fairly well developed. Most of the beekeepers own modern movable frame hives and produced a fair quality of honey. In the remainder of the state, except a few scattered counties, beekeeping is relatively undeveloped. Most of the beekeepers of the state produced comb honey alone. It has been necessary therefore for the speaker to make recommendations to beekeepers in all stages of development.

In order to present improved methods to the beekeeper in a concrete form demonstration apiaries are established in the different sections of the state to demonstrate the different advanced methods of handling bees. Sometimes a demonstration apiary begins its history with the transferring of bees from box or cross comb to modern movable frame hives. At other times the demonstration apiary begins with a group of neat looking factory made hives.

Throughout the year demonstrations are held in these apiaries and modern methods applied. Some of these demonstrations are:

Spring Feeding
Providing extra space for brood
Adding supers as needed
Swarm Control
Care of the surplus crop
Requeening
Fall Feeding
Packing
Providing windbreaks

Meetings are held at these apiaries occasionally both to demonstrate new methods and to show the results obtained by using these methods.

The success of the demonstration apiaries has depended largely upon the type of men selected for the demonstrator. A careless or partially disinterested cooperator will seldom get good results regardless of the time spent with him. Three years would be considered a minimum of time to run a demonstration apiary. The average production of the demonstration apiaries for 1930 was 51 pounds per colony compared to 23 for the State as a whole.

Foulbrood control work has also taken considerable time since the disease is now scattered over the entire state. Demonstrations, lectures and personal visits have been used in this work.

One of our big problems in Pennsylvania is to encourage the production of extracted honey instead of comb honey alone since many sections of the state are not especially well adapted to comb honey production. To meet the problem we do not recommend a complete change from comb to extracted honey but encourage the additional use of shallow frame supers, one shallow frame super to be placed on the bees first. Under this to be placed the section supers as needed.

Extractor building demonstrations are also held in the different communities to help start beekeepers extracting. This is the case especially where no extracting has been done in the community before. Complete extracting outfits are built in connection with the extracting demonstrations.

After a program has been carried on in a county for a few years and the beekeepers interest seems to be lacking, Junior 4-H Bee Club work is organized and carried on for two or more years. The junior work invariably increases materially the interest of the adults besides being of value to the club members directly. The average production for club members for 1929 was 75 pounds per colony, this season 57 pounds per colony.

A large number of beekeepers are also reached by mimeographs which are put out regularly during the busy season. The mimeographs reach the beekeepers who can not be reached by meetings or visits, they help also to maintain interest in the work where it is being done or has been done in past years.

Other fields receive less time, marketing often comes to the front. Improvement in the grades and methods of packing are emphasized as a step to better marketing. The use of parafine and cellophane for comb honey is becoming widely adopted in the state as well as the use of glass for strained honey. Other recommendations for marketing are made to suit the particular communities.

Auto tours, displays, field meetings, etc., are used where needed to help the general program. Winter meetings and bee schools are held at which time the seasons work is outlined and the different demonstrations explained. Interest is developed in new communities by means of the winter meetings, or talks given to the Granges or similar groups. Bee schools are also held. They serve as a forerunner of the summer demonstrations. They prepare the beekeepers for the work so that demonstrations are better understood than they would be if the beekeepers had not heard of them before. All the steps center towards a development of the beekeeping in all its phases and stages of development.

CHAIRMAN. Those going to Medina will leave at 8:30, taking the interurban at the west side of the square.

CHAIRMAN. The last paper will be read by the chairman since Mr. G. H. Vansell is not present.

APIARY INSPECTION, COSTS, AND RESULTS IN CALIFORNIA

By G. H. VANSELL, *Davis, Calif.*

California long suffered under lax bee disease legislation and most extensive migration. The individual county system of apiary inspection may have been just what was needed at the time of its inception, during the 80's, when disease was rare and transportation facilities made locations practically stationary. As conditions changed, new problems naturally arose. At various times efforts were made to improve the inspection system but this was not accomplished until 1927, largely through the efforts of the California Beekeepers Association.

The new system provides a State Apiary Inspector in the California State Department of Agriculture for supervision and coordination of the work in the various 58 counties. The Agricultural Commissioner of each county was automatically made ex-officio state bee inspector in charge of local inspection through his deputies. The Commissioner already had charge of such work as fruit and vegetable standardization, weed control, plant pest quarantine, etc., so that he was very familiar with the detail of procedure.

An opportunity for uniformity in cooperative clean-up work and enforcement when necessary was thus afforded through officers long experienced in other agricultural regulatory and service fields.

At the outset, clean-up campaigns were inaugurated in counties or districts where conditions seemed to warrant. Inspection of every colony was pushed and the practice of burning the combs and bees of all colonies infected with American foulbrood was encouraged. Table 1 pictures the original findings, results, and costs to date more clearly than words.

In the main, results are highly gratifying. Support of the beekeepers is in some areas unanimous. However, a small percentage of objectors have vigorously pushed prosecution for damage from loss through burning. The predominating feeling is that this loss is really gain in view of the striking disease reduction. Recently a prominent eastern apiculturist revisited our State and remarked that the producers seem possessed of "the smile that won't come off," when the disease situation is brought up.

TABLE 1. DATA FROM REPORTS OF THE STATE BEE INSPECTOR, FRANK E. TODD.

Comparative Summary California Bee Inspection Progress (Since burning has been practiced)

Year	Apiaries Inspected	Apiaries American Foulbrood Infected Number	Apiaries American Foulbrood Infected %	Colonies Inspected	Colonies American Foulbrood Infected Number	Colonies American Foulbrood Infected %	Inspection Costs Per Colony	Inspection Costs Total*
1928	8840	3395	40.21	281,388	14,160	5.0†	16c	$44,000
1929	9527	1962	20.5	311,845	7,619	2.44	18c	$56,000
1930	9105	1468	16.1	310,319	4,547	1.46‡	18½c	$58,000

*Funds for this work are derived from 52 different sources. It is difficult to obtain an accurate total, as when necessary, more money is spent than budgeted and also at times the complete budget is not used.

†1928. One County had average less than 1%; 28 Counties had averages over 3%; highest County average 57.5%; lowest County average .91%.

‡1930. Eleven Counties had averages less than 1%; 6 Counties had averages over 3%; highest County average 6.25%; lowest County average 0%.

CHAIRMAN. We will now hear the report of the committee on resolutions.

E. L. SECHRIST. The resolutions committee present the following resolutions.

RESOLUTIONS

Resolved, That the apicultural section of the American Association of Economic Entomologists commend the action of the association in arranging for the apiculture section to have a whole day as a separate meeting and we urge that this policy be continued as it has resulted in an unusually good attendance.

Resolved, That the members of the apiculture section of the American Association of Economic Entomologists hereby express our regret at the loss by death of our esteemed members James S. Hine and N. E. Shaw and direct that these resolutions be transmitted to the families of the deceased.

Resolved, That we appreciate the courtesy of the Case School of Applied Science in arranging for the use of the commodious auditorium of the Electricity Building for the meetings of the apiculture section.

E. L. SECHRIST, *Chairman*
G. E. MARVIN
E. J. ANDERSON

E. F. PHILLIPS: I move the resolutions be adopted.

E. N. CORY: I will second the motion.

CHAIRMAN: The motion has carried.

CHAIRMAN: I will hear the report of the nominating committee.

E. F. PHILLIPS: The nominating committee recommends S. W. Bilsing of Texas A. & M. College for chairman and J. M. Robinson of Auburn, Alabama for secretary.

E. N. CORY: I move that the nominees be accepted as recommended and that the secretary cast the vote for them.

CHAIRMAN: The motion was seconded and has carried.

E. R. ROOT: Those coming to Medina will have an opportunity to see the new type of candles made from beeswax and also the modern methods of removing honey from the comb.

CHAIRMAN: If it is the wish of the members the meeting will adjourn until the time of the next meeting in New Orleans.

Adjourned 5:20 P. M.

THE EFFECT OF LOW EXTERNAL TEMPERATURES ON THE BROOD-NEST TEMPERATURES OF A NORMAL COLONY OF BEES DURING SUMMER

By W. E. DUNHAM, *Ohio State University*[1]

ABSTRACT

The purpose of the experiment was to determine the brood-nest temperatures of a normal colony of honeybees, when a fairly constant low temperature, below that of the ordinary climatic temperature, was maintained around the hive.

PROCEDURE. A normal colony of bees was selected for this experiment. The colony had a moderate supply of honey and pollen, was strong in worker bees (30,000-45,000), brood-rearing was active, and the queen was in a healthy condition. Such a colony, in a ten-frame standard hive was placed in a cold chamber. From the cold chamber an extension of the entrance was made which ended out of doors in a four by three-eighth inch opening. This allowed the bees to carry on their normal activities such as gathering nectar, pollen, water, etc.

By electrical thermometers, the temperatures in the brood-nest could be obtained without approaching the hive, thus eliminating the possibility of disturbing the bees. Any disturbance would probably have brought about an abnormal condition which would result in abnormal temperatures. There were eight thermocouple wires running into the brood-nest at equally distributed points but all were placed at the same depth from the top of the hive, which was four and one-half inches. Beginning August 20th and extending to September 1st., temperatures were taken every hour from each wire. This made a total of 2304 readings taken in the brood-nest during the period of the experiment. During the first five days of the experiment (August 20-24), the temperature in the cold chamber was the same as that of the room in which the experiment

[1]The writer wishes to acknowledge his indebtedness to Prof. W. M. Barrows for helpful suggestions and encouragement in every phase of this problem.

was conducted. A fairly constant low temperature was maintained during the remaining seven days of the experiment.

At the beginning and close of the experimental period, careful notes were taken on the exact position of the honey, of the brood, and also the stage of development of the latter. In order to make a clear diagnosis of the brood temperatures, it was necessary to class these temperatures into two distinct groups; those occurring in the central brood area, and those occurring in the outer brood area. The curves which are shown in Figure 43 give a graphic picture of the daily average temperature of the central broad area, the daily average temperature of the outer brood area, the daily average temperature of the cold chamber, and the daily average of out door temperature.

Discussion. The temperature curve of the central brood area shows a remarkable constancy even when the external temperature varies over a wide range. During the first five days of the experiment, when the colony was subjected to external temperatures which were much higher than during the remaining seven days of the experiment, the average daily temperature range of the central brood area was between 93.5°F. and 94°F. For the remaining seven days, when the colony was subjected to low external temperatures, the daily average temperature of the central brood area ranged from 92.8°F. to 93.4°F. Thus it can be seen that the difference in degrees from the lowest to the highest temperatures recorded in the central brood area was only 1.2°F. By the very careful comparison of the curve of the central brood area with the curves representing the external temperature to which the colony was subjected one might be led to believe that there was a very slight correlation between the former curve and the external temperature curves. Slight correlation is present but the variations in the brood area curve are so small as to be almost negligible. It is very remarkable that during the last seven days of the experiment, when the colony was subjected to low external temperatures, the difference between the lowest and the highest temperatures recorded in the central brood area was only .6°F.

During the first five days of the experiment, the daily average temperature of the outer brood area remained quite constant, there being only a difference of .6°F. between the highest and the lowest temperatures recorded. This small difference in the variation in the temperature of the outer brood area indicates that the external temperatures which occurred during the first five days of the experiment had very little influence on the daily average temperature of the outer brood area. However, it is inter-

esting to note that the lowest temperature occurring in the outer brood area, which was 91.4°F. occurred on the same day as the lowest external temperatures recorded.

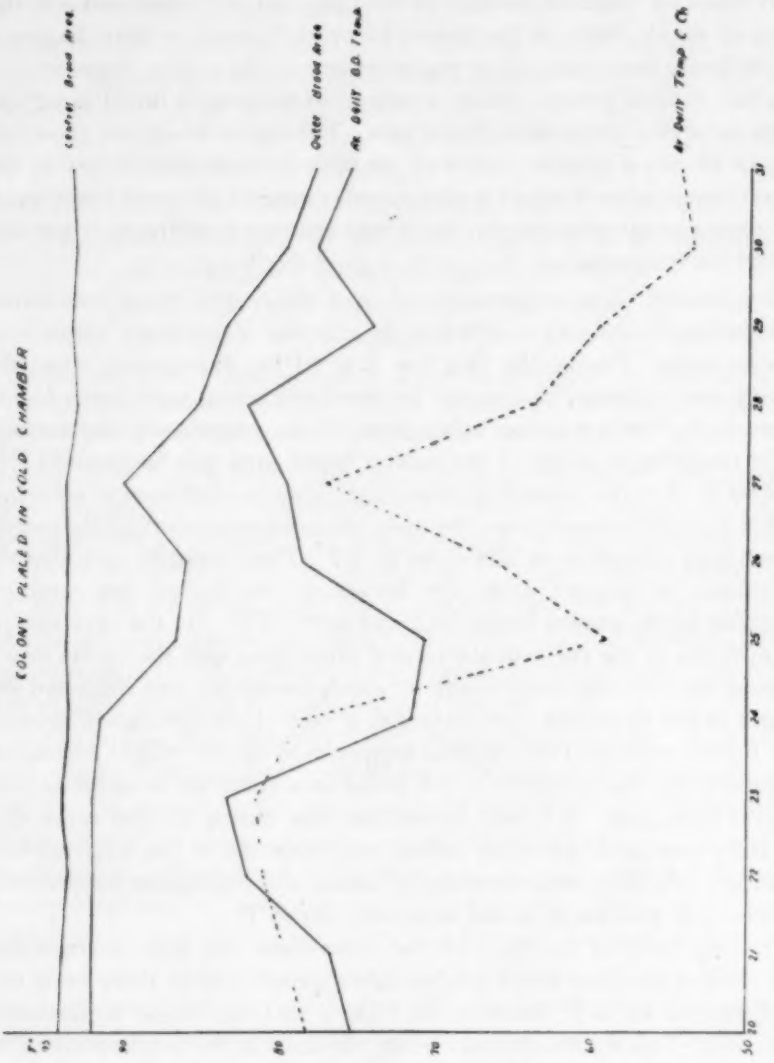

FIG. 43.—Colony placed in cold chamber.

In comparing the curve which represents the temperatures occurring in the outer brood area with the curve representing the temperatures of the central brood area, it is shown that there is a difference in the tempera-

ture of these two curves ranging from 1.6° to 2.3°F. This difference is very significant as it shows clearly that the temperatures occurring in the entire brood area are not uniform. The warmest and most uniform temperatures occurred in the central part of the brood area, while as seen by the curves, the cooler temperatures occurred in the outer brood area.

In order to understand the curve representing the daily average temperature of the outer brood area during the remaining seven days of the experiment, it is necessary to explain the exact condition of the colony in its brood rearing activities at the beginning and the close of the experiment. At the beginning of the experiment, brood rearing was going on actively and in the region which is classified as the outer brood area there was brood in all stages as well as eggs which indicated that the queen had been in this region. The writer has assumed that during the first five days of the experiment, since the external temperatures were normal, that brood rearing activities were approximately the same for these five days, as were indicated when the colony was examined at the beginning of the experiment. The check colony which was subjected to normal temperatures verified this. The examination at the close of the experimental period showed that in the central brood area, brood rearing was going on actively while in the outer brood area, judging from the age of the brood present, there had been no brood rearing going on after low external temperatures are applied. On the outer edge of the outer brood area, the bees were less active due undoubtedly to cooler temperatures. The bees in the broodless area where there were no thermocouple junctions were even numbed by the low temperature. The reaction of these numbed bees is well known to beekeepers. When disturbed, they raised the end of the abdomen and exposed the sting on the end of which little drops of poison could be seen and the odor of the poison was very pronounced.

As seen in the curve of the outer brood area, (Aug. 26th) there is a rather sudden drop in the temperature when low external temperatures occur. In a previous article[2] the writer has shown that the temperature in the broodless area drifts (the extent depending on the strength and condition of the colony) with the rise or fall of external temperatures. It is obvious that the temperatures in the broodless area of this colony were much below the temperatures which occurred in the outer brood area. It is logical to infer then that these cooler temperatures in the broodless area which borders the outer brood area tend to bring about a

[2]Dunham, W. E.—The Influence of External Temperature on the Hive Temperatures during the Summer. Jour. Econ. Ent. 22:798-801. 1929.

lowering of the temperature of the outer brood area. In addition to this, there is a more or less constant interchanging of bees from one region into the other. As was observed at the close of the experiment, the bees in the broodless area were nearly inactive, which would show that the body temperature of these bees corresponded very closely to the temperature of the area they were in. This would mean that when these bees from the broodless area migrated into the outer brood area they immediately received heat by conduction from this area which warmed their bodies to the temperature of the outer brood area. However, as the bee's body tends to reach the temperature of this region, its muscular activity increases but the heat liberated by this activity does not equal the heat taken into the bee's body by conduction. Thus the temperature of the outer brood area would be lowered but the extent would depend on the temperature of the broodless area. Obviously the temperature of the broodless area has a direct influence on the temperature of the outer brood area, since, as previously shown, the temperature of the broodless area fluctuates with the external temperature.

When comparing the outer brood area temperature curve with the low external temperature curve, it is shown clearly that the influence of low external temperatures on the temperature of the outer brood area increases as time goes on. This can be explained easily since observations at the close of the experiment showed that there had been no brood rearing going on after low external temperatures were applied. This would mean that as time went on more and more of the brood would have emerged and had the experiment been prolonged the final result would probably have shown that what was originally the outer brood area would have become a broodless area. This could be called a period of transition since as the brood emerged the empty comb space would gradually become increasingly greater and the final result would be a broodless area. With this transition, when the outer brood area became a broodless area, there would be obviously a transition of temperatures.

In a typical clover region as the fall season advances toward winter, there is a marked tendency toward cooler temperatures and normally, in early fall, there are killing frosts which cause the plants to cease producing pollen and secreting nectar to any appreciable extent. This experiment is quite comparable to what takes place in a colony of bees in the fall, and helps to explain what causes the cessation of brood rearing during that period of the year. The low temperatures which occur in the fall period would be more variable than the low temperatures in this experiment. The majority of night temperatures would at least be as low

as those to which this colony was subjected and would quite frequently verge toward the freezing point, and sometimes might be below it.

As has been inferred already, when low external temperatures occur brood rearing ceases in the outer brood area and a transition from the original outer brood area to a broodless area occurs. The brood area which formerly bordered the outer brood area thus becomes the new outer brood area. There is a series of these transitions from an outer brood area to a broodless area during the fall. This constant trend of transitions due to lower and lower external temperatures causes successive contractions of the brood nest. Eventually the external temperature becomes so low and remains so constant that brood rearing ceases entirely and so a broodless condition of the colony results.

Section of Extension

EXTENSION WORK IN OX WARBLE CONTROL

By C. C. COMPTON, *Illinois State Natural History Survey*

The past decade the ox warbles, *Hypoderma bovis* and *H. lineatum*, have increased in abundance over most of northern Illinois. Within the last few years dairymen in general have come to a better understanding of their harmful effects on cattle, particularly dairy animals. Studies made by the writer during this period indicated that, in the case of dairy animals, at least, control by the application of insecticides was practicable. Since 1925 a number of ox warble schools have been held in northern Illinois. At these schools an effort was made to acquaint dairymen with the losses inflicted by these insects and with the best known control measures. These meetings have always been held at some dairy farm and the materials to be used in control work were actually demonstrated. In a number of cases an ox warble movie was shown to good advantage.[1] Following the demonstration each dairyman present was given a small quantity of the material used and instructed to treat one animal. Immediately following this treatment I examined as many of the animals as time would permit, pointing out the mistakes that had been made, such as, failure to remove the "scab" over the aperture made by the larva, failure to work the material into the aperture or larvae that had been missed entirely. The demonstration of control measures are always more effective if the persons present are given an active part in the demonstration.

As a result of these schools there were a number of dairymen treating their animals for warbles. Sometimes there would be several dairymen

[1]Film of the U. S. D. A. Extension Service, Ox Warble—A Million Dollar Tune

grouped together who would employ control measures but in many cases the men who were treating their animals were scattered, usually with untreated herds near by. Under such conditions the results were variable. Where several herds, situated in a somewhat isolated group, were treated there was a marked reduction in the warble population after the first seasons treatment. A considerable reduction also followed where single herds were treated providing the pasture did not adjoin that of an untreated herd. Where single herds were treated and where the pasture adjoined that of an untreated herd there was no appreciable reduction in the warble population.

In one case in Cook County a single herd of 26 Holsteins so surrounded by truck farms that no other dairy animals occurred within a radius of 1 mile, were entirely freed of warbles in three seasons. When the treatments were started the average number of warbles was 6.7 per head. After the first seasons treatments the warble population in the herd was reduced to an average of 1.3 per head. That year two heifers were added to the herd and showed a total of 18 and 21 warbles respectively. The third season two animals were infested with 2 and 3 warbles respectively. The fourth year no warbles showed up. Unfortunately these studies terminated here as the herd was disposed of and the land sold for subdivision purposes.

In the fore part of 1929 one of these ox warble schools was being held in cooperation with Mr. V. J. Banter, Farm Adviser of the Stephenson County Farm Bureau. Over 90 per cent of the dairymen in the southern half of Silver Creek Township were present at the meeting. At the end of the demonstration the interest of the attending dairymen was such that they requested aid in starting control operations immediately. The dairymen present agreed to treat their herds at once and I agreed to visit each herd within a week after the first treatment to check up on their efforts. One of the men present agreed to distribute the materials and to visit all the dairymen in this immediate area who were not present at the school and interest them in the control program. Farm Bureau members were to receive the ointment free of charge and nonmembers were charged cost price. The material used was Gusanol, a proprietary derris extract ointment. Previous experience with ointments and dusts of various kinds had shown that the ointments are most satisfactory in the hands of dairymen for the treatment of dairy animals.

With this rather sudden beginning the project was started. Plans were then formulated with the Farm Adviser for carrying on the project. One dairyman was selected as the project leader with four assistants or co-leaders situated at strategic points in the township. The project

leader together with the co-leaders was advised by telephone of the time for making subsequent treatments. They, in turn, called the remaining dairymen on the telephone, each one a definite group, and relayed the information to them. In this section it is necessary to start control operations about the 20th of February, and continue at 30-day intervals until about the first of July. In cases of this kind where treatments are given at monthly intervals it is necessary to prompt the men regularly in order that too long a time will not lapse between treatments. In this connection I wrote to the Farm Adviser a few days before each treatment was due. His office secretary then called the project leader and co-leaders by phone advising them that the next treatment should be made on a certain date. Each of the leaders then passed this information on to a definite small group of dairymen.

Again previous experience had shown that it is necessary to check the work of the dairymen until they have had some experience in making applications. For this reason I visited each herd within a week after each treatment and checked all the animals. Any live warbles found were either extracted or carefully treated with the derris ointment. It has been found in this work that the dairymen achieve varying results with the first treatment but with this practice more uniform results followed. There are few dairymen who will not miss occasional warbles. In order to have all animals in the barns at the time each check-up was made it was necessary for each dairyman to know the exact date and approximate hour of my visit. This information was circulated through the project leaders as herein described—by letter to the adviser, by phone from the advisers' office to the project leaders and thence by phone from the project leaders to the individual dairymen.

The results after one season of treatments were probably not so striking as might be obtained were the treatments made by one man experienced in this line of work. In checking results I used untreated herds somewhat removed from the treated herds. By comparing the average number of warbles per animal under three years old in the treated herds with the average number per animal under three years old in the untreated herds both in 1929 and again in 1930, it was evident that the reduction in warble population amounted to approximately 66%. This figure is only approximate because of the many factors that enter into the intensity of warble infestations. In this type of extention-control work time will not permit accurate counts of live and dead warbles following each treatment. One encouraging result obtained was the favorable attitude of the dairymen who felt that a good start had been made in the control of these insects. Treatments were

continued in 1930 with the dairymen applying the control measures without the monthly check-up. The results of this work will not be obtainable until 1931.

It is the hope of the Farm Adviser and interested dairymen that the start made in Silver Creek Township will prove a nucleus that can be enlarged until the campaign for ox warble eradication becomes county wide.

J. A. HYSLOP—This paper represents what the Federal Extension Office considers the ideal type of organization and procedure to follow in doing extension work. A well laid out plan has been followed and carried to its conclusion.

F. C. BISHOPP—The work reported here well illustrates the possibility of undertaking and carrying out the control, if not complete extermination, of the ox warble within certain areas selected for the undertaking.

DIRECTING RED SPIDER CONTROL THROUGH THE USE OF SPECIAL TAGS ON NURSERY STOCK

By E. L. CHAMBERS, *Madison, Wisc.*

In order to meet the public's demand for satisfactory control methods we must, it appears, offer something readily obtainable, simply prepared and easily applied that will give immediate relief at a very low cost and without endangering in the least the plants to be treated. These wishes on the part of the public are being rapidly commercialized and "ready to use" remedies of all types, good for almost any trouble that may exist among the plant kingdom, are being offered to meet this demand. If the claims are strong enough and the package sufficiently attractive the item of price makes little difference. Regardless, however, of the prohibitive cost of these products on a large scale we must admit that many of these prepared combinations, although perhaps consisting of only an arsenical mixed with sulphur, have been a godsend to the small backyard gardener whose need requires only a very small quantity and can consequently buy the ready mixed material, where its separate ingredients are not obtainable, and perhaps enough for his use at the cost of one of the ingredients in the quantity he would have to purchase. In addition, these ingredients are properly mixed in accurate proportions whereas the amateur gardener might have to guess at the measurements and guess wrong.

Finding a happy medium in the use of extension methods governing methods of insect control to refrain from the use of trade names of in-

secticides, to avoid adverse publicity and to prevent injury through lack of care in following direction on the part of careless individuals, is the problem we are compelled to face when dealing with pests attacking nursery stock. If we raise a question of doubt as to the wisdom of planting shrubs susceptible to certain serious pests, we are pessimists; if we caution the use of treatment recognized as requiring considerable care, we are alarmists; and if we just tell the public how it is being done and the directions are not followed completely, then we are called something else.

While it may be feasible to advise the planting of the more resistant varieties of trees and shrubs, we must use discretion in discouraging the planting of even such well known shrubs as the common snowball bush, which apparently is seriously attacked by aphids wherever it is grown, since unless we can offer a suitable substitute, such as the Japanese snowball, we are criticized by our nurserymen and purchasing public who want a snowball bush and feel that it is up to us to provide one that is immune to aphid attack.

Probably one of the groups of nursery trees giving us the most problems in the way of pest control are the evergreens which have become so very popular for landscape work and developing that "out-of-door living room" the nurserymen have been encouraging through their publicity campaigns.

On these evergreens the outstanding pest and one which was proving to be a limiting factor in the growing of ornamental spruce trees in Wisconsin was the common red spider (*Tetranychus telarius*). At first oils were recommended with excellent results wherever used as directed and much publicity was given this method of control through the newspapers and propaganda prepared for the nurserymen. The number of complaints where injury developed because of failure to apply the oils as directed caused the nurserymen to be dissatisfied with these recommendations because they said their customers either did not follow directions and got injury or else they read the cautions accompanying the recommendations and decided not to take the chance of removing, temporarily, the blue down on their blue spruce and other injuries as a result of adverse temperatures, too strong a mixture, etc.

In an attempt to find a way of offering a service to the growers of evergreens without prejudicing the public against buying them because of their tendency to be attacked by the red spider, we decided upon a special tag to be attached to every lot or single specimen of evergreen sold carrying in a few words some helpful suggestions. Headed "Keeping Evergreens Healthy," we had printed on yellow tags of standard

size in black ink a brief description of the symptoms of red spider injury, attempting to explain that this pest was prevalent everywhere and did not come to them on the nursery stock and that by simple methods their injury could easily be avoided. The use of water under pressure, spraying with glue, and dusting with sulphur were the three ways suggested since these methods could be applied handily by anyone without elaborate equipment. We used no trade names and we suggested the necessity of repeated applications. As an experiment, 25,000 of these tags were distributed gratis to the nurserymen of our state last season so that one could accompany each lot or specimen of evergreens and they proved very popular with the nurserymen and public. The tag also carried the information that control measures of other pests of nursery stock could be obtained from the nursery inspection office upon request.

The advantages of a tag as we see them are that since the space is limited on its face the text has to be brief and being a bright yellow color, it stands out and attracts attention against the green foliage of the bundle. When the reader notices that it gives direction for retaining their characteristic color, which they have been unable to do previously, they hang it up on a nail for future reference. Spray calendars, on the other hand, have a limited use in that they must include a great variety of pests on a wide range of host plants and as a result are rarely read unless attention is called to some specific part of it.

Nursery agents and dealers selling stock over the counter report that these tags are doing much to break down the prejudice so commonly held against the evergreens because of a lack of timely knowledge for the control of the red spider and as a result this year the nurserymen are having their own supply of tags printed and are requesting us to prepare special tags for other classes of stock which will lend themselves to simple treatments.

W. E. BRITTON—Is ground bone glue better for this than fish glue or liquid glue?

E. L. CHAMBERS—Either one can be used.

J. S. HOUSER—Have you tried lime sulfur sprays as a control?

E. L. CHAMBERS—Yes, but we had burning of the foliage at a strength of 1 to 40.

OUTBREAK OF CORN EARWORM IN MISSOURI

By L. HASEMAN, *Columbia, Mo.*

During the past twelve months Missouri has experienced two unusual seasons; the cold winter of 1929–30 and the dry summer of 1930. The severe winter greatly reduced the number of overwintering stages of insects but the hot, dry summer, on the other hand, materially aided many of our worst pests. Of the various pests benefited by the favorable summer none have multiplied so abundantly as the grasshoppers and the corn earworm.

The corn earworm is often abundant enough to do serious damage to the corn crop but it seldom does much damage to other crops in Missouri. The drought of 1930 was especially serious on the corn crop and with an unusual development of the earworms they turned to other crops. Late corn was severely damaged and early in the fall the pest was found to be serious on tomatoes all over the state. The late crop was unusually severely damaged. Both ripening and small green tomatoes were infested. After killing frosts put an end to their outdoor work they turned to tomatoes grown under glass and not only attacked the fruits but they also bored into the tender growth of the plants.

INJURY TO SOYBEANS. Early in the fall it was found that, in the southeast counties of the state where the soybean has become an important crop, the earworms were doing serious damage to the crop. The late varieties in particular suffered. Thousands of acres of soybeans grown for seed were practically a complete loss. In some fields practically every pod was infested and every bean in the pod eaten out by the worms. The damage was especially serious near corn fields or where soybeans were seeded in corn. Thousands of dollars worth of seed beans have been lost and there will be a shortage of seed, especially of the late varieties, next year. While ordinary garden beans are often attacked by the earworm, this was the first serious damage to soybeans in the state.

The attack came so unexpectedly and suddenly that there was little chance to undertake control work. However, should the earworm reappear as a serious pest on soybeans, growers are planning to dust the crop with arsenate of lime.

WORK ON ALFALFA. In a few scattered localities the worms did some damage on alfalfa and in former years the pest has been found abundant on red clover, feeding more or less exposed on the foliage.

INJURY TO GERANIUMS. One of the most unusual departures of the pest in the last two years has been its work on the foliage and in the stems of geranium. Both outdoors and in the greenhouse the worms have been feeding on geraniums of different varieties. In the greenhouse it has also done considerable damage to the blossoms of different flowers such as the Calendulas. Their unusual numbers during the past summer and fall probably accounts for most of their work on new crops but they show a tendency to enlarge the group of plants and flowers on which they are able to feed and develop normally.

In Central Missouri a superabundance of the worms entered the soil in the fall to pupate and recent examinations show these pupae to be in a healthy condition. Where the pest was abundant in corn and soybeans, farmers will be advised to plow the infested fields this winter when and where plowing is practical.

W. P. FLINT—Is fall plowing a control measure that can be applied in the north central states? We have not been able to get pupae to winter north of the latitude of St. Louis and very few south of there in our state. We feel that our infestation comes from migration of moths northward and observe that these moths are at dusk attracted to petunia blossoms to feed.

W. H. LARRIMER—The infestation in the northern states is likely due to migration of moths from the south. Fall plowing as a control would probably be of little value north of the Ohio River. Only three or four per cent of the larvae which enter the soil in the fall in central Virginia emerge as moths the following year. However this insect has great ability to reproduce and develop a large population.

W. E. BRITTON—We have not been able to bring these pupae through the winter in Connecticut.

W. E. HINDS—The earworm is a serious pest of hairy vetch in Louisiana during the early spring. It is with us during the entire season.

T. H. PARKS—We have examined string beans shipped from southern Mississippi to Akron, Ohio in early May and found them ruined by corn earworm larvae that had hatched from eggs unsuspected when the shipment was started.

H. F. DIETZ—This insect has at times become a greenhouse pest of many flowers and must be dealt with on roses and carnations especially.

F. C. BISHOPP—Fall plowing fits well into the farming practices of the south. We should advocate fall plowing wherever we can because it is a good practice.

DEVELOPMENT OF ARGENTINE ANT CONTROL AND ERADICATION IN MISSISSIPPI

By R. W. HARNED, *Agricultural College, Miss.*

(Paper not received for publication)

SYMPOSIUM: THE EFFECT OF THE 1930 DROUGHT UPON INSECT POPULATION

THE EFFECT ON CEREAL CROP INSECTS

By W. H. LARRIMER, *Washington, D. C.*

The season of 1930 will long be remembered by most farmers in the Central and Eastern United States as the year when the weather, the crops, and even the markets were all against them. The activities of a great number of species of insects were doubtless affected by the record drought of 1930—some beneficially, some adversely, and in the cases of a great many more there is a question whether they were affected abnormally at all. Those insects which are favored by dry seasons added to the farmer's burden by their unusual abundance and, because of the demoralizing influence of the combination of these unfortunate circumstances, little or no attention was given to the absence of those insect pests usually abundant but which were unfavorably affected by the extreme dry season. In this paper consideration will be confined to some half-dozen species generally rated as most important, as follows: the corn earworm, Hessian fly, grasshoppers, chinch bug, wheat jointworm, and the European corn borer.

CORN EARWORM. Oviposition was very light throughout most of the drought area during the heat period of July to early September after which, it increased appreciably and became concentrated on late corn and other hosts available in the attractive stage at that time. Unusually heavy mortality of pupae was observed between September 15 and early November, and considerably more than the usual number of moths emerged prematurely. The general lack of host plants late in the season resulted in more than the normal infestation in those hosts available and also in more than the usual variety of hosts. It is not certain whether the dry season or the late fall was responsible for the occurrence of injurious infestation farther northward than usual.

HESSIAN FLY. Throughout most of the main wheat growing area of the country, the 1930 drought inhibited Hessian fly activities materially

with the result that, in general, fall infestations were low. Spring infestations were light to begin with, except in a few restricted regions, due to the lingering effects of the 1929 drought and the not particularly favorable spring of 1930. Puparium dissections indicated an unusually high summer mortality of puparia in some locations, evidently due to high temperatures and desiccation. Lack of moisture until mid-September prevented early pupation and emergence of flies, growth of volunteer wheat, and preparations for wheat sowing over the larger part of the wheat belt. As a result there was no early multiplication of flies in volunteer wheat except in a few sections receiving more or less local rains, where, under more favorable moisture conditions, there was more early volunteer wheat, early sowing, and heavier fly infestation.

The general rains of mid-September caused a wide-spread but rather light main emergence in the last part of September and early October but a portion of the flies in the stubble did not pupate last fall and continued droughty conditions in October over the greater part of the wheat growing region, were unfavorable to establishment of this main fall brood, or further pupation and emergence.

In general, the drought was unfavorable to summer survival, fall emergence of flies, and the establishment of the fall brood.

GRASSHOPPERS. Grasshoppers seem to have profited by the drought of 1930. Starting off by a not too favorable hatching period, nevertheless, as the summer advanced outbreaks of a more or less serious character occurred. There was no widespread demand for control measures but reports of local increase in abundance, reports of damage, and demands for control measures were received from practically all states in the drought area. If weather conditions should be favorable during the spring and early summer of 1931, grasshoppers may be expected to occur in outbreak abundance almost anywhere in the country.

CHINCH BUG. At the beginning of the season 1930, the chinch bug was present but was considered of very little or no menace over most of the drought area. As was to be expected, the dry season was very favorable to chinch-bug development and injurious abundance built up in time to hasten the loss of crops, probably already doomed, in central Missouri, parts of Illinois, Kansas, and Oklahoma.

WHEAT JOINTWORM. The larvae of the jointworm were well matured before the more severe stage of the 1930 drought occurred. The extreme heat which accompanied the drought, resulted in the death of a small per cent of the larvae after maturity, but this light setback was at least partially overcome by the occurrence of only two, instead of the

usual three, generations of *Ditropinotus aureoviridis* Crawford, one of the most important parasites of the jointworm. The net result seems to be that the status of the jointworm was very little affected by the drought.

EUROPEAN CORN BORER. The corn borer in the drought area of 1930 was adversely affected by the hot, dry season, and where the drought was most severe the borer was hardest hit. The stunted plants and dry season made scouting for new infestation much more difficult than usual. The corn borer moths were not normally active; consequently very little spread was observed for the season. Oviposition was very much reduced, many eggs dried up or fell off the plants, and the survival of the larvae that hatched was far below normal. The resulting infestation, as compared with former years in the area of heavier infestation, may be reviewed briefly by referring to the following table. Over a large portion of the area known to be infested, the infestation is still too light to be measured.

THE STATUS OF THE CORN BORER FOR THE SIX-YEAR PERIOD, 1925–1930

States	Average Number Borers Per 100 Plants					
	1925	1926	1927	1928	1929	1930
Michigan	1.18	11.80	24.90	13.97	15.68	12.41
Indiana	—	—	—	.33	.57	.76
Ohio	2.17	7.30	5.02	7.54	12.89	5.40
Pennsylvania	1.91	5.40	5.49	.74	.96	.68
New York	1.82	5.15	10.24	9.38	9.21	10.23
Averages for Area	1.77	7.41	11.41	6.39	7.86	5.90

—In this year no survey was conducted.

It will be seen that the situation in general is slightly better than at the close of the season of 1926. This is largely due to the 1930 weather conditions being unfavorable to the insect. If 1931 is a favorable season, the corn borer situation may well be anticipated with considerable misgiving.

THE EFFECT ON CEREAL CROP INSECTS

By W. P. FLINT, *Urbana, Ill.*

The summer of 1930 was one of the driest and hottest ever recorded in Illinois. The prolonged dry period and extremely hot weather had its effect on many of the insects which are always present in more or less numbers. Notes on the effect of the drought were made at each of our field stations, by Mr. S. C. Chandler in southern Illinois; Mr. J. H. Bigger in West central and Mr. C. C. Compton in northern Illinois, and notes were also made by several other members of the staff in the course of their work about the state.

GRASSHOPPERS. In southern Illinois grasshoppers have been rather scarce for several years. There was no noticeable increase in numbers this season.

In central Illinois the grasshoppers increased very noticeably but were not abundant enough to cause any serious damage. They were particularly numerous in the west central counties where conditions were ideal for egg laying.

In northern Illinois, especially in the northwest counties, there was a very noticeable increase and conditions during the first part of October were ideal for egg laying.

The species most abundant in central and northern Illinois was *Melanoplus femur-rubrum*. The dry, hot weather on the whole favored grasshoppers and the rate of increase was greater than in normal years.

HESSIAN FLY. In the fall of 1929 considerable infestation was found in wheat sown nearly up to the recommended fly free date. This year, at the time of our annual Hessian Fly Survey in August, many dead larvae were found in the stubble. These had apparently died from the effects of heat and drought. Infestation has been reduced in the southern part of the state so that a high infestation is found in only four counties on the extreme west side of the state within a radius of 50 miles of St. Louis.

In central Illinois there was a very heavy mortality during the summer and only small numbers of fly can be found at this time (Dec. 1st) except in the extreme west counties, where moderately heavy infestation exists.

In northern Illinois 51 per cent of the fly was found dead at the time of the August survey, most of these apparently being killed by the heat and dry conditions. Only a very moderate infestation of fly is to be found at this time.

On the whole, the drought conditions were very unfavorable to the fly and so reduced their numbers as to check what appeared to be an incipient outbreak.

CHINCH BUGS. Dry weather and chinch bugs are always associated in the minds of Illinois farmers. The present weather has been the most favorable to the chinch bug of any which we have experienced for many years and they have taken full advantage of this favorable weather to increase very rapidly. Only moderate to small numbers of bugs went through the winter of 1929–1930 and in April, 1930, there appeared to be no danger of chinch bug damage in any part of Illinois. They have increased, however, to an extent where a serious outbreak can be expected in at least ten of the central and south central counties.

The man-made environment which is now provided for the chinch bug gives it an abundance of succulent green food for both the first and second brood of bugs, even in the driest years, and dry, hot seasons are therefore extremely favorable to this insect.

WHITE GRUBS. So far as our observations show, white grubs were not greatly affected by the dry weather. There was no evidence that the grubs were killed in the dry hot soil and a sufficient amount of plant growth was present to provide food for the grubs throughout the season.

JOINT WORMS. No special observations were made on the joint worm in southern Illinois.

In central Illinois many joint worm larvae were apparently killed by the dry, hot weather. In northern Illinois where the drought was not so severe, the season was rather favorable to this insect and notes made in a number of fields during the first two weeks in August showed 84 per cent of the joint worms alive in the fields at that time.

LEAFHOPPERS. In southern Illinois the leafhoppers were apparently not affected to any noticeable extent by the drought conditions.

In central Illinois there was a very great increase in abundance of leafhoppers, especially in orchards. Mr. Bigger's notes state that there was a very great increase and that they are now more abundant than they have been for several years.

In northern Illinois leafhoppers were somewhat more abundant early in the season and about normal late in the season. No special observations were made on the effect of the drought on other field insects for all parts of the state.

In central Illinois the lesser clover leaf weevil was greatly reduced in numbers, many of the larvae dying before pupating, and a still greater number of the insects dying at the pupal stage. Adults are hard to find in hibernation this fall.

The dry fall has apparently been very favorable to the clover leaf weevil and the larvae are much larger than usual for this time of the year, and also more abundant.

The clover seed chalcid and clover seed midge were greatly reduced by the dry weather and are much less numerous than usual.

Summing up, the drought conditions in Illinois for the past summer have helped to reduce the numbers of Hessian fly and some of the clover insects, but have brought about the menace of a severe chinch bug outbreak and a moderate grasshopper outbreak. On the whole we would expect greater damage from insects in 1931 than would occur had the season of 1930 been either wet or a normal year. As appears from the

present conditions, we are likely to have a much greater money loss caused by a smaller number of species than would have been the case had we not experienced the severe drought during the summer of 1930.

THE EFFECT ON LEAF-HOPPER POPULATIONS FOR 1930

By HERBERT OSBORN, *Columbus, Ohio*

The very unusual dry season of the past summer resulted in a marked effect upon the leaf-hopper populations over a very wide extent of country. In the vicinity of Columbus there was a marked decrease in fields which were suffering from dryness and there is every reason to expect that this paucity of numbers will be evident for at least one to two seasons to follow. Through a fortunate arrangement of the Bureau of Entomology I was enabled to make a motor trip through a considerable extent of the drought affected area. Commencing at Columbus, Ohio, the route led west through Indiana, southern Illinois, central Missouri and as far as Ottawa County, Kansas; then south to the southern border of the state and east to southern Missouri, with a short trip into northern Arkansas. The return was made through the Ozark region and south-eastern Missouri, across western Kentucky as far as Lexington and then north to Columbus.

Throughout a great part of this area pastures and meadows had suffered very severely from effects of drought. In many cases no leaf-hoppers at all were to be found. In other cases, where there was some sparse growth of grasses or forage plants, a few leaf-hoppers were present. The species most evident was *Euscelis obscurinervis* which was the most abundant species in all localities and which appeared to have survived much better than any of the other species, probably because of its wider range of food plants.

Deltocephalus inimicus, which is ordinarily found in great abundance, especially in all blue grass pastures or meadows, was remarkably scarce. Only a few individuals were taken, and these generally where the topography was such that some survival of grasses was possible. In the western sections, especially in central Kansas, where the drought had not been so continuous, there was a large percentage surviving. This applies specially to the species occurring on the native grasses. These species, however, have become adapted, by long centuries of residence in the semi-arid country, to conditions of frequent aridity.

For species occurring on alfalfa and clover there was a somewhat better survival, doubtless due to the greater succulence of the host

plants. *Platymetopius frontalis, Agallia sanguinolenta, constricta* and *uhleri* were found in moderate numbers.

These notes refer particularly to the species occurring on the cereal or forage crops but a somewhat similar scarcity was noted in other species where the vegetation had become dry or withered as a result of lack of moisture. On the whole it may be said with assurance that the leafhopper population was very materially affected and in a great many fields I believe was practically exterminated. A period of possibly two to five years may be necessary for a reestablishment to the normal numbers for many of the species. It will be an interesting matter to follow this reestablishment during the next few years, and, while no absolute percentage comparisons can be made with what might be considered normal population, I am confident that some comparisons of general importance may be possible.

EFFECT ON SHADE TREE AND FOREST INSECTS

By J. S. HOUSER, *Agricultural Experiment Station, Wooster, Ohio*

The outstanding occurrence this past season in Ohio with respect to the influence of the abnormally dry weather on shade tree and forest insects was an invasion of bark beetles in conifer plantings on the state forests, which are located principally in the southern part of the state. *Pinus resinosa* has offered great promise and up until this season has proven exceptionally free from damage by insect pests. In mid September, however, the ten year old plantings of this species at Steece, Lawrence County, were found rather heavily infested with *Ips grandicollis* Eich., some trees having died during late summer. Upon closer examination the infestation was found to be rather wide-spread over an area of several acres. Larvae, pupae and adults were found. By December the damage had become more intense and additional numbers of trees had died. As a result of this infestation it will be necessary to remove a large number of trees from a stand which up until this time has been practically complete. *Pinus strobus* in adjoining plantings was not observed to be infested. *Orthotomicus caelatus* Eich. and *Hypophloeus* sp. were taken from *P. resinosa* at Steece and *Ips calligraphus* Germ. at Mineral, Ohio. At Mineral *I. grandicollis* Eich. was taken on *P. resinosa* and also upon *P. erecta*. The determination of the species discussed was made by Dr. M. W. Blackman of the Bureau of Entomology.

The correlation of damage by bark beetles and dry weather is well known through the observations of Hopkins, Felt, Blackman, Craig-

head, St. George and others. Practical advantage is taken of this knowledge by the practice of watering for the control of such species as the hickory bark beetle, *Scolytus quadrispinosus* Say.

In general the numbers of leaf eating caterpillars were significantly smaller throughout the forest areas of the state than normal. I refer particularly to such species as *Anisota senatoria* Abb. & Sm., *Heterocampa manteo* Dbldy, *Halisidota maculata* Harr, *Halisidota caryae* Harr and *Symmerista albifrons* Abb. & Sm. The locust leaf beetle, *Chalepus dorsalis* Thunb., which frequently is excessively abundant in southern Ohio did practically no significant damage this past season. The walking stick, *Diapheromera femorata* Say, which has been sufficiently abundant in certain sections of the Scioto Trail Forest near Chillicothe of recent years to cause 75 per cent defoliation was much reduced in numbers as was also Le Conte's sawfly, *Neodiprion lecontei* Fitch, which in 1928 and 1929 caused the loss of some pines in the plantings.

Of the pests of shade and park trees in Ohio, the principal variation of 1930 from other years was an increase in the number of complaints that newly set street trees were attacked by borers and some evidence was obtained to indicate that scale insects increased somewhat in abundance. Red spider was not troublesome in the Cleveland area until September, although some nurseries in the state reported rather severe infestations earlier in the summer which disappeared during the period of heat and drouth of mid-season.

THE EFFECT UPON FRUIT INSECTS

By W. S. Hough, *Winchester, Va.*

The drought inhibited the development of the following fruit insects.

Plum Curculio (*Conotrachelus nenuphar* Hbst.) The general absence of peaches followed by the hot, dry weather from July through September combined to reduce the population considerably. It is thought that the extreme dryness of the soil where the drought was most severe was unfavorable for the emergence of adults from July to September.

Oriental Fruit Moth (*Laspeyresia molesta* Busck) The marked reduction in numbers of this insect was probably due to the following conditions: (1) cold weather during the period when spring brood moths were present reduced oviposition, (2) the hot, dry weather hardened the peach twigs during the period of second brood infestation which caused a great mortality of second brood larvae, (3) this mortality was

further increased by scarcity of peaches. Infestation in apples was very light in Virginia and also in Indiana where apple and peach trees were interplanted.

APHIDS. Checking of growth was unfavorable for *Aphis pomi* DeG. Decrease in the numbers of fall migrants of *Anuraphis roseus* Baker and *Rhopalosiphum prunifoliae* Fitch was probably due to the scarcity of green food plants of the summer generations.

The insects listed below were favored by the drought.

CODLING MOTH (*Carpocapsa pomonella* L.) This was very abundant in most sections, egg laying being continuous from the middle of May to the early part of October.

SAN JOSE SCALE (*Aspidiotus perniciosus* Comstock) A conspicuous increase in population occurred in September.

FRUIT TREE BARK-BEETLE (*Scolytus rugulosus* Ratz.) Reported on cherry, peach and plum, and in restricted localities where apple trees were weakened by a severe outbreak of pistol case bearer (*Coleophora malivorella* Riley) and then by the drought. Not serious in commercial orchards generally.

LEAFHOPPERS (*Typhlocyba pomaria* McAtee, *Erythroneura obliqua* Say, *E. dorsalis* Gill. and *E. hartii* Gill.). In August and September reported in increasing numbers. Specking of apples was more or less general in September. Where the drought was most severe in Virginia the leafhopper population did not equal that of some previous seasons. The foliage was hardened to such an extent and growth checked so that our most common species, *T pomaria* failed to develop in large numbers. In regions just north of Virginia where the drought was not quite as severe, this species appeared in exceptionally large numbers, especially in orchards near rivers and streams where the foliage was greener and more succulent. The infestation was so severe that it was necessary to remove the excrement from thousands of bushels of fruit before packing.

EUROPEAN RED MITE (*Paratetranychus pilosus* C. & F.) More abundant than usual throughout the drought region.

EFFECT ON THE WHITE GRUB POPULATION

By J. J. DAVIS, *Lafayette, Indiana*

(Paper not received for publication)

EFFECT UPON TRUCK CROP INSECTS

By P. D. SANDERS, *College Park, Maryland*

(Paper not received for publication)

THE EFFECT ON THE MEXICAN BEAN BEETLE

By NEALE F. HOWARD, *Bureau of Entomology, U. S. Department of Agriculture*

The prolonged drought of 1930 materially checked the development of the Mexican bean beetle (*Epilachna corrupta* Muls.) over a great part of the infested area in the East.

While the dry weather delayed emergence from hibernation quarters in the spring, generally speaking, winter survival was high. However, even with the large numbers of beetles present early in the season, reproduction was checked and consequently the bean crop suffered little damage. It is believed that the low humidity and extremely high temperatures were responsible for this, and that either factor alone could have been responsible for the lack of normal development of the beetle. It appears, however, that the prolonged high temperature during the summer months was probably the more important of the two factors. Temperature in bean fields exceeded 100°F. on many occasions during July and part of August in Ohio and reached 121°F. at Columbus, Ohio, July 20.

In Ohio atmospheric evaporation was 55 per cent higher between late May and the middle of September than the average for a similar period during the preceding four years. At several points in Ohio, Virginia, and Maryland actual field observations showed that the beetle eggs were unable to hatch, and in some instances large numbers of adult beetles succumbed to the conditions prevailing at the time of the drought.

In August, when lower temperatures and rains occurred, the surviving beetles commenced to reproduce with characteristic rapidity, and from late September to the middle of October all stages were abundant in southeastern Ohio.

SUMMARY OF SYMPOSIUM DISCUSSION

LEAFHOPPERS IN FORAGE CROPS. In Montana the population of leafhoppers on sugar beets was reduced by the drouth of this year. (W. B. Mabee)

In Wisconsin the young alfalfa plants were affected less with alfalfa yellows disease than in former years. The older plants were very

badly yellowed. The recent drouth was in many ways similar to the insect tragedy that follows cutting of grasses. (A. A. Granovsky)

The depletion of leafhopper population in forage crops will likely hold over for another year. Both the cutting and dying of grasses destroys many leafhopper eggs. (H. Osborn)

WHITE GRUBS. That the drouth had no apparent effect upon the population of white grubs was the opinion expressed by members present. The grubs are able to move upward or downward in the soil to adjust themselves to suitable moisture and temperature conditions and the roots furnished sufficient food for them during the period of extreme drouth. (J. J. Davis)

GRASSHOPPERS. There is apparently evidence in Indiana and Wisconsin that grasshoppers come in cycles of several years which is not entirely dependent upon weather conditions. The year 1930 coincided with a gradual increase in this cycle. (Davis & Granovsky)

Grasshoppers were more abundant in Indiana in 1931 than formerly. (C. M. Packard) More abundant in Ohio than since 1926. (T. H. Parks) They were scarce in West Virginia in 1930. (L. M. Peairs)

The food supply provided by grasses died and they concentrated in the green crops that remained, thus being more noticeable. (G. S. Langford)

In our trip over the central states we found plenty of grasshoppers, but few eggs. Were the eggs deposited as usual and are they in healthy condition? (H. Osborn) Plenty of eggs were laid in Montana. We have little data from most of the area. (W. H. Larrimer)

CODLING MOTH. That the insect had greatly increased in all states visited by the drouth was the opinion of those present. This injury came largely in late summer and frequently from 25 to 30 per cent of the fruit was blemished in the well sprayed orchards in the southern section of the drouth affected area. (Various members)

Codling moth is greatly affected by temperature. Under high temperatures of late summer a higher per cent of the larvae which hatch from eggs live to enter the fruit than during the cooler period of May or June. We had a sizable third brood of this insect in the latitude of Virginia and it extended over the states to the west including the Ohio Valley. (W. S. Hough)

ORIENTAL FRUIT MOTH. In Virginia, apples were not infested with Oriental Fruit Moth larvae even where interplanted with peaches. (Hough)

We have heavy infestation in apples in parts of Maryland where they are interplanted with peaches. (E. N. Cory)

Oriental Moth was not much affected by the drouth in Tennessee. Early peaches were heavily infested. (W. W. Stanley)

January freeze destroyed the peach crop and this, as well as the drouth of midsummer, contributed to reduce the numbers of this insect. (J. J. Davis)

SHADE TREE INSECTS. The Elm Leaf Beetle was worse this year than for ten years. It is my belief that this is due to a period of three years during which it has been dry during the time of pupation of the insect. (W. E. Britton)

In Louisiana we have an increase of the southern pine bark beetle following dry periods. (W. E. Hinds)

Commercial Companies who deal with tree plantings are now recommending watering hickory trees to control the hickory bark beetle. (J. S. Houser)

TRUCK CROP INSECTS. The Mexican Bean Beetle was almost wiped out by the drouth in Maryland. Potato tuber moth has greatly increased. The corn earworm was quite abundant, but we are not sure that we can attribute this to the weather conditions. (P. D. Sanders)

The Mexican Bean Beetle was also adversely affected by the drouth in Tennessee, but it was able to make a rapid recovery and in September the population was again high. (W. W. Stanley)

SUGAR CANE BORER. The sugar cane borer population in Louisiana was very low in 1930. Trichogramma parasites were not as abundant as usual, apparently due to the scarcity of the eggs of the cane borer.

The severe freeze of December 1929, which froze the cane in the fields, destroyed most of the borer population in the cane. It is quite likely that this setback resulted in the cane borer not being able to increase sufficiently to damage the 1930 crop. The drouth may have had its effect, but such natural control is more likely to be effected through the extreme rather than the mean temperature. (W. E. Hinds)

A STATE PROGRAM OF INSECT CONTROL

By T. H. PARKS, *Ohio State University, Columbus, Ohio*

ABSTRACT

A few well planned projects of long time duration constitute the control program. Existing related agencies are utilized to aid in carrying them to the public. Examples are given of how insect control information is disseminated.

Insect control work in Ohio is planned with reference, (a) to the importance of the crop losses, (b) whether or not the loss is preventable, and (c) whether or not the control method is economical to apply.

Our extension work has largely passed from personal service calls of miscellaneous nature, based upon unexpected outbreaks, to a well planned program composed of a few projects in which we utilize various existing agencies that can further this program. These agencies include, for example, the entire group of Ohio entomologists, which we utilize in the Hessian fly survey for collecting information, down to the retail insecticide dealer, who gives information over the counter when making sales. The accompanying outline of methods and agencies used shows the ways in which we aim to reach growers, in both the fields of specialized and general agriculture, and the assistance we ask for and secure from other groups working with the public.

An example of some of the methods followed will illustrate: First, the summer wheat insect survey, participated in by the Ohio entomologists, gathers the information of Hessian fly abundance and enables us to map the area where a campaign of control must be made. Second, the November Hessian fly survey, which is carried on entirely by the extension specialists and agents, determines what happened to wheat sowed at different dates. This survey has much research value. In collecting this data we frequently utilize local Smith Hughes instructors or other agricultural teachers and their classes. The pupils are shown how to find Hessian fly in the young wheat and are provided with samples of wheat sowed at different times in their community. From this we ask them to determine the percentage of infestation, which they do under our supervision. After a two hour laboratory period it is safe to assume that these boys understand the Hessian fly control method which we are emphasizing. Third, the records secured by us are published locally through the cooperation of the county agricultural agents and are given state-wide publicity, if, in our judgment, this is advisable.

An example of an entirely different type of work is that done under the name of the Ohio Spray Service. During the spring of 1929, to

OHIO EXTENSION SERVICE

Insect Control Work done by Extension Specialists and County Agents Cooperating

Insects		*Methods Used*	*Agencies Utilized*
Hessian fly	(a)	Summer survey	Ohio entomologists
	(b)	November survey	Local leaders & Agr. classes
	(c)	Publicity work	Newspapers, radio & schools
Corn insects	(a)	Lectures	Farmers' institute speakers
Fruit insects	(a)	Ohio spray service	Mail, telephone and radio
	(b)	County agent's fruit school	Ohio entomologists
	(c)	Local fruit schools	Local fruit growers' associations
	(d)	Insecticide dealers' schools	Insecticide dealers
Veg. crop insects	(a)	Insect and disease control demonstration truck	Local vegetable growers' associations
	(b)	Bean beetle control demonstrations	" " " "
	(c)	Local vegetable grower's schools	" " " "
	(d)	Special canning crop protection meetings	Local canning companies
	(e)	Insecticide dealer's schools	Insecticide dealers

better prepare our county extension agents for this service, we brought 18 of these agents to the University and gave them three days of intensive schooling. They studied the life history and control of fruit insects and diseases together with work on insecticides, fungicides and the spraying program. At the conclusion of this school the agents were required to write practice spray letters and were given hypothetical problems and questions, such as would be raised by progressive fruit growers. As a result of this course the agents were well qualified to serve as disseminators of the spray service information. The specialists in entomology and plant pathology cooperated in giving this school and are jointly responsible for the instructions and time notices carried in the Ohio Spray Service.

The chief function of the spray service is to better time the fruit sprays. The timing of some of the apple scab and codling moth sprays is determined through local data collected by special observers and forwarded to the specialists. In entomology, these data consist of records of daily emergence of the broods of codling moth adults, together with the 7 P. M. temperatures at egg-laying time. During 1929 and again in 1930, we established codling moth observation points in five widely scattered areas of the state. The daily emergences and temperatures at these stations were forwarded to the specialist, who prepared the insect control part of the spray letters and determined the time for their release in each section of the state. In addition to the mails, the telephone and the radio served as important methods of getting the information to the growers.

The results of this work have been highly gratifying. We are constantly striving toward eliminating possible errors in timing our sprays through the use of better technique in providing more natural conditions for the emergence of the insects used at our observation stations.

A third example, and one showing the kind of service offered our truck growers, is the use of an insect and disease control demonstration truck. This consists of a large truck fully equipped with insecticides, fungicides, sprayers and dusters and with both a plant disease and insect specialist accompanying it. The truck followed a schedule which took it to the commercial vegetable growing centers near our largest cities at the season of the year when the insect and disease problems are becoming uppermost in the minds of the growers. At these demonstrations insecticides and fungicides were discussed and home-made dusts, such as different strengths of nicotine dusts and the home-mixed fungicide dusts, were prepared in the presence of the growers. Different types of sprayers and dusters were demonstrated

and the commercial grower was able to see for himself the ones most suited to his needs. We invited the local dealers to exhibit their wares and found them willing cooperators.

In the canning crop communities special meetings arranged through canning company officials were held for the benefit of growers of cucumbers, cabbage and tomatoes grown for the factories. Cooperation with the canning factory managers during 1930 resulted in the use of 45 tons of calcium arsenate and gypsum dust mixture for controlling the striped cucumber beetle on contract acreage. These materials were purchased wholesale by the factories, where they were mixed and distributed to the growers at a cost of but 1c per pound. Previous to our cooperation with these factory managers, the growers were using lime on cucumbers. The results with the calcium arsenate and gypsum mixture convinced them of the superiority of this method.

The examples given are chosen from among those methods used in controlling insects of staple crops, fruits and vegetables. The outline indicates what other methods are being used and the agencies that are asked to cooperate. Those who have known extension work in early days will be impressed by the changes in methods that have come about during the sixteen years since the passage of the Smith-Lever Act. We believe this evolution to be a natural one and to make for better results in insect control. The problem of insect losses is large enough now and appears to be growing larger. Effective insect control calls for the combined efforts of various agencies that deal with agricultural or commercial problems. The specialist will find his efforts multiplied by formulating his extension program to utilize these agencies to disseminate the proper information.

IS TRICHOGRAMMA BECOMING A FAD?

By HARRY S. SMITH and STANLEY E. FLANDERS, *University of California Citrus Experiment Station, Riverside, Calif.*

ABSTRACT

Unless a conservative attitude is maintained biological control can easily become quackery. Some of the work with Trichogramma seems to be tending in this direction. It is pointed out that the control of pests by the use of Trichogramma is a complicated problem, and until this is fully appreciated there is little prospect of sound conclusions being reached as to its practical value.

Even entomologists are not proof against the dictates of fashion. In a recent paper, Dr. W. R. Thompson made the statement that "*** the idea of biological control has now become fashionable and is

tending to degenerate into a kind of superstition or fad."[1] While we believe firmly in the usefulness of this method of insect control, and are convinced that only a mere beginning has been made in its application, we also believe that it is important to recognize its limitations and its dangers. With its plausibility, its spectacular nature and, because of these, its strong appeal to the agriculturalist, biological control can very easily become mere quackery.

There is reason to believe that some of the extensive work with Trichogramma in various parts of the world is tending in this direction. The interest which has been aroused in the practical use of this insect since methods were developed for its mass production has been tremendous. There is hardly an important agricultural country in the world in which there is not an attempt being made to use Trichogramma as a means of controlling some lepidopterous pest, and in North America there are at least a dozen such projects. This in itself is of course not objectionable; but, if one may judge from many of the publications on the subject, there is little hope of arriving at a sound conclusion as to the real value of Trichogramma as a means of pest control until a greater appreciation of the complexity of the problem is had. In this connection, both the *collection* of data and their *interpretation* present difficulties.

In the experiments so far reported on, the procedure has been about as follows: Certain plots are set aside for Trichogramma colonies and other plots are reserved for checks. The parasites are liberated in the test plots and after a certain time has elapsed, counts are made in both test plots and checks, the percentages of parasitism are compared and the conclusions are drawn from these figures. Such experiments are ordinarily of little or no value. The percentage of natural parasitism by Trichogramma is notoriously erratic, even when observations are made at the same time, in the same vicinity and in apparently similar environments. Counts reported upon in one instance showed a range in parasitism of from 0% to 51.4% in the same general vicinity, on the same kind of host plant and within a period of two weeks. That there is this extreme variation is a matter of common knowledge. Because of this fact, one cannot logically conclude that an excess of parasitism in a colonized field over a check field is significant of the effect of the colonizations. Only an extensive series of replications of such experiments can establish the fact that the colonizations have actually caused an increase of parasitism.

[1]Ann. Appl. Ent., XVII, p. 306, 1930.

Another important point that must be considered is the nature of the dispersal of Trichogramma from the colony. We are convinced that there is no justification for the suggestion that "the species then spreads northward with the prevailing air movement during the summer." There is not the slightest doubt but that Trichogramma successfully over-winters in host eggs as far north as Canada. As a matter of fact, dispersal of Trichogramma is probably less extensive than that of almost any other winged insect. Our experience has indicated that the dispersal from colonies of 1000 to 30,000 parasites, colonized on a single card, is largely limited to a space having a diameter of about 25 feet. Occasional Trichogramma females may of course be carried considerable distance by the wind, but they exhibit a very strong tendency to cling tightly to their support in air currents and the great majority of them will remain within a few feet of the place where they were colonized. In collecting field samples for the determination of the extent of parasitism, it is very important that this characteristic of Trichogramma be borne in mind. Unless the locations of the colonies are so close together as to cause the "spheres of action" to overlap, one can very easily be led into error in the interpretation of his data. Eggs collected in the immediate vicinity of the colony may show a high parasitism, but it is a mistake to assume that this represents fairly the conditions throughout the plot.

Another important point bearing on the question is that of host population density. Under ordinary conditions the *percentage* of parasitism tends to vary directly with the host population density, assuming that parasites have been present in the plots for a sufficient length of time. If, then, it happens that the plot in which Trichogramma is colonized has a considerably more dense population than the check plot, it would normally be expected to develop a higher per cent of parasitism than the check plot, without the liberation of additional Trichogramma, and this higher percentage of parasitism may be mistakenly attributed to the colonizations when as a matter of fact it would have occurred even if none had been added.

Up to the present time the work with Trichogramma has been carried out on the basis of two hypotheses: One, that low percentages of parasitism are due to failure of Trichogramma to over-winter in sufficient numbers and that this failure can be overcome by artificial colonization of Trichogramma in the spring, thereby bringing about an increased percentage of parasitism which will then be maintained throughout the season. The other, that by frequent colonization of large numbers of Trichogramma a continuously high percentage of parasitism

can be maintained during the period in which such colonizations are being made.

The writers believe that ordinarily the high percentage of parasitism by Trichogramma during the fall months is determined by the high population density of the host insects at that season and, conversely, that the low percentage earlier in the season is determined by the sparse host population. If the host population density is a limiting factor in the determination of parasitism percentages, then there is little hope of maintaining a high percentage of parasitism throughout the season by early colonization of Trichogramma. Such colonizations may conceivably increase the parasitism temporarily, but their effect is not likely to persist for more than a generation or two. A parasite of the characteristics of Trichogramma, which finds its host almost entirely by random movements and which has an extremely limited "sphere of action," operates in a way very comparable to the operation of a contagious disease; that is, the nucleus of a colony is practically always present and, given a favorable environment, its abundance in a general way becomes inversely proportional to the distance separating the individuals of its host species, in other words is determined by the density of the host population. If this is true, then it would be futile to attempt to bring about an increased percentage of parasitism which will be maintained throughout the rest of the season through the medium of early colonizations of Trichogramma.

In this connection the reader is referred to Chapman's work on Tribolium[2]. Using a series of artificial environments of similar size and character, he stocked these with 1, 2, 4, 8, 16 and 32 pairs of beetles. The small original populations of beetles saturated the environments in short periods of time producing populations equal to those in environments which started with many times greater initial populations. There is involved here what we believe to be something in the nature of a general principle of biology. That is, within certain limits population density is determined by the nature of the environment rather than by the number of parents of the organism under consideration.

We believe, therefore, that it is extremely unlikely that the colonization of additional Trichogramma in the spring can influence the Trichogramma population for more than a generation or two, and that experiments indicating such an effect need to be carefully scrutinized for influences which have been overlooked.

The second objective of the Trichogramma work, that of bringing about and maintaining a high percentage of parasitism by frequent

[2]Ecology 9, p. 117, 1928.

colonization of large numbers of Trichogramma, is, we believe, much more likely to be achieved. While under natural conditions the percentage of parasitism is influenced largely by the frequency of opportunities for parasite and host to meet, and this is determined largely by the density of the host population, this difficulty is overcome by maintaining such a dense and well distributed population of Trichogramma that sooner or later every egg is reached by a parasite. It might be thought that such treatment would result in practically 100% parasitism. This does not necessarily follow. Everyone engaged in the propagation of Trichogramma has probably been impressed by the fact that even when his host eggs are confined in the small space of a petri dish and this environment is then stocked with one adult parasite to each four host eggs, he still often fails to get 100%. An apple tree which we stocked with 50,000 Trichogramma developed less than 40% parasitism. However, 90% to 98% parasitism has been observed often enough in the field under natural conditions to justify the belief that ordinarily, if a sufficient number of Trichogramma per unit of area are colonized and properly distributed in both space and time, a high percentage of parasitism could be expected. The difficulty at the present time is that no one knows either what is a sufficient number or just how uniformly they must be distributed. These are points which need careful and extended investigation, and after that is done we will be confronted with the question as to whether this high percentage of parasitism really gives results of practical value, and whether it is economically feasible to produce it.

All of the previous discussion has been concerned with *percentages* of parasitism. Percentages of parasitism, however, do not necessarily measure the practical results of parasite colonization. Assuming for the moment that by supplying additional Trichogramma we can increase the percentage of parasitism, the conclusion that such a result necessarily has an important bearing on the control of the pest can easily lead us into serious error. In conducting experimental work of this kind, it must be recognized that natural checks do not operate independently of each other. The efficiency of a check is very often, in fact generally, dependent upon the intensity of other checks operating against the same species. A reduction in intensity of one check may be accompanied by an increased intensity of another check and, conversely, by increasing the intensity of one check we may bring about a reduction in intensity of another to such an extent that the total effect is scarcely or not at all altered. An increase in parasitism brought about by the colonization of additional Trichogramma is of value only to the extent

that it is followed by a reduction in the total population of its host. It is essential, therefore, that the increase in parasitism be accompanied by a reduction in the population density of live host insects remaining in the test plots as compared with the checks before it can logically be concluded that the liberation of Trichogramma was of actual practical value.

Our experience with Trichogramma in California as a practical means of pest control has not been encouraging. However, we wish to avoid giving the impression that we believe there is no possibility of making practical use of this interesting little parasite. We have merely attempted to point out that the problem is much more complicated than it appears on the surface, both from the standpoint of collection of the data and of their interpretation in terms of practical results. Up to the present time we have seen no convincing evidence that practical results have been achieved, but there remains an enormous amount of painstaking work to be done before one can say positively that the mass production and colonization of Trichogramma is or is not worthy of a place in the general pest control program.

In view of the present state of our knowledge concerning the practical value of the propagation and colonization of Trichogramma, we believe that there is an ethical point involved in connection with the responsibility of the economic entomologist to the public which will appeal to all conscientious entomologists. Years of contact with growers here in California have taught us that the mere idea of biological control has a remarkably strong appeal to them. This is easily understood, in view of some of the striking results that have been had. But the entomologist knows what many growers do not realize, that biological control is of limited applicability. He cannot then, if he has a high standard of professional ethics, permit the grower, because of his well known receptivity to such ideas, to gain an erroneous impression of the status of the Trichogramma work. So long as the work is experimental and its practical value undetermined, we believe that publication in growers' or other industrial journals should be avoided. Newspaper publicity should be discouraged. The idea is so plausible that it is difficult to avoid arousing their hopes to a high pitch, which often has an unfortunate after effect.

We believe also that our responsibility goes even farther than this. There is at the present time evidence that commercial interests are undertaking to capitalize on the great wave of popular enthusiasm which the Trichogramma work has created. There is, of course, not the slightest objection to the commercialization of biological control where it is of proved value, but it takes a very elastic conscience to

justify the sale of Trichogramma to growers on the basis that it won't do them any harm and may do some good. Such activities should be unqualifiedly condemned. One can just as easily justify the manipulation of the human spine for the control of intestinal worms. In our present state of knowledge, both are quackery.

TRENDS IN CODLING MOTH CONTROL IN THE PACIFIC NORTHWEST[1]

By R. L. WEBSTER, *Pullman, Wash.*

ABSTRACT

The use of lead arsenate and oil sprays for the codling moth (*Carpocapsa pomonella*) in the Pacific Northwest was increased greatly during the last few years. In the Wenatchee-Okanogan district over four million pounds of lead arsenate were used in 1930 and fourteen thousand barrels of oil spray. While a considerable part of the oil was used for dormant treatments, there is a decided tendency toward the use of the oil-lead arsenate combination for codling moth control. The oil-nicotine combination has proved fully as efficient as lead arsenate for the cover sprays in the second brood. It is recommended to replace lead arsenate because of the arsenical residue situation. Codling moth traps are depended upon in the Yakima and Wenatchee Valleys to date cover sprays, and have proved very useful in this connection. There are approximately eight hundred stationary spray plants in the Wenatchee Valley.

Because of the size of the apple crop in the State of Washington, the control of any insects which affect that crop is of utmost importance. Most of the apples are grown in two general regions in the state, both under irrigated conditions, known as the Wenatchee and the Yakima Valleys. In 1930 the apple crop in the Wenatchee-Okanogan district was estimated at 24,000 carloads. For the remainder of the state, and including the large district of the Yakima Valley, the estimated figure is about 20,000 carloads. The commercial crop in Washington is, as many of you know, larger than that of any other state.

Because it is necessary to ship these apples long distances, high standards have been enforced in the Pacific Northwest, and boxed apples must be reasonably free from blemishes caused by the codling moth and other insects. This condition of affairs makes it imperative that the Washington fruit grower be more than usually alert in all his spraying operations. Probably nowhere in the country have spraying operations been developed to so high a degree. Again, with the general use of the spray gun in these irrigated valleys, high pressures are neces-

[1]Published as Scientific Paper No. 184, College of Agriculture and Experiment Station, State College of Washington.

sary, and spraying outfits constructed to deliver from 300 to 400 pounds are in general use. In addition, the development of stationary spraying outfits has made more efficient the spray applications formerly accomplished with portable outfits. There are approximately 800 stationary spraying plants at the present time in the Wenatchee Valley and a large number are being installed in the Yakima Valley.

Cover Sprays. At the present time in the heart of the apple-growing district six cover sprays are applied in addition to the calyx spray. In districts more or less isolated, where the altitude is higher, the number of cover sprays is reduced. In the Okanogan Valley one or two cover sprays are sufficient, since the second brood of the codling moth is relatively slight. On the other hand, in the lower Yakima Valley spraying may actually be continuous during the season in years favorable to the development of the insect.

Quantity of Lead Arsenate Used. The large acreage of apple trees is reflected in the amount of lead arsenate used in the state. In Yakima County in 1929 1,300,000 pounds of lead arsenate were used, according to figures compiled by the State Department of Agriculture. It is estimated that probably 2,000,000 pounds of lead arsenate were used in this county in 1930. When we add to this some 500,000 pounds used in the lower Yakima Valley, there is a sum total of 2,500,000 pounds as the amount of lead arsenate used for spraying purposes during the season of 1930. Even more is used in the Wenatchee-Okanogan district. In 1928 the total in this district amounted to 2,100,000 pounds; in 1929 the figure mounted to 2,600,000 pounds; and in 1930 a still greater increase to 4,063,000 pounds.

Use of Traps for Timing Cover Sprays. Five years ago it was customary with many growers to adhere to what was called a ten-day program for making applications of lead arsenate during the season. This policy was recommended in order to keep fruit and foliage protected from worms and stings during the entire season. With the general use of the moth traps as indicators of moth emergence, first pointed out by Spuler in 1926, it was possible to use this information as a guide throughout the season by means of which cover sprays could be more accurately timed. The use of these traps in this way has been of immense value to the apple industry in checking damage by the codling moth.

In the Wenatchee Valley, the State Department of Agriculture has placed these emergence records in conspicuous places along the highways where the daily records may be readily noted by orchardists in the immediate vicinity.

Several large organizations also make use of these trap records as a basis of making recommendations to their own growers. The American Fruit Growers' Organization employs one man who devotes a large share of his time to collecting this data from orchards in various locations in the Wenatchee Valley. The "Big Y" organization (Yakima Fruit Growers' Association) last summer utilized a string of traps in the Yakima Valley covering 17 locations from Kennewick, in the lower valley, with an altitude of less than 400 feet, to Naches, near Yakima, at an altitude of about 1400 feet. This is an organization of some 1300 growers holding about 13,000 acres of bearing orchards which produce between 5,000 and 6,000 carloads of fruit annually. Mr. A. L. Deaver, who directed this work, tells me that this organization depends entirely on the use of the traps in making recommendations to growers for timing cover sprays.

Oil-Lead Arsenate Combination. The experience of growers has shown the great difficulty of preventing worm entries by the second brood of larvae. Detailed insectary experiments by Mr. Spuler have shown that between 40 and 50 per cent of the worms placed on apples sprayed with lead arsenate at the rate of two pounds to 100 gallons of water actually gained entrance without being poisoned. The difficulty in checking the insect during the summer has led to the use of the oil-lead arsenate combination. At the present time we are recommending a spray application consisting of lead arsenate, used at the rate of two pounds to 100 gallons of water, to which is added one gallon of commercial summer oil containing approximately 75 per cent of actual oil. This combined spray serves both as an ovicide and as a larvacide, since there is sufficient oil in the combination to kill a large share of the codling moth eggs and a sufficient amount of lead arsenate which serves to check those larvae which attempt to enter the fruits. The oil-lead combination serves best when used at the peak of egg deposition, a time which may be determined fairly accurately by a careful study of moth emergence records during the season.

Apples sprayed with the oil-lead arsenate combination, particularly if several applications have been made, may be difficult to wash. This is especially true when the oil-lead combination is used for the second brood. Where this combination has been used previous to July 25, as recommended by the various state and federal authorities in Washington, there has been no difficulty in reducing the arsenic load to below the tolerance with the ordinary washing methods. Where late applications of this combination have been made, or where there has been

undue delay in washing the fruit, cases have occurred where removal of the residue has been a difficult matter.

Oil Spray Conference. Most of the progress in the investigation of oil sprays is due to the activity of the various members of a group of entomologists, chemists, and horticulturalists, representing the Washington, Idaho, Montana, and Oregon Experiment Stations, the Dominion Experimental Farms in British Columbia and the U. S. Department of Agriculture, who have participated annually in the meetings of the Northwest Oil Spray Conference held in Spokane for the last four years. It is due to the combined work of these various men that oil sprays are being recommended under specified conditions in the Pacific Northwest and are being utilized on a large scale. A year ago definite specifications on viscosity and sulfonation test for dormant and summer sprays were made by the group.

In 1929, 55 carloads of oil were used in the north central Washington district and this amount was increased to 113 carloads in 1930. In barrels of oil, this amounted to more than 14,000. Although this figure includes oil applied during the dormant season, by far the larger share of it has been applied during the summer months. Disregarding the fact that more lead arsenate is being used for codling moth control in the Pacific Northwest than ever before, still there is a decided trend to the use of the oil-lead combination, which should be restricted to the early season cover sprays, and to the nicotine-oil combination, applied after July 25.

Oil-Nicotine Combination. The desirability of using some non-arsenical for the late cover sprays has led to the use of the oil-nicotine combination, which Mr. Spuler has found in his work to be very effective in codling moth control. As already pointed out, lead arsenate in combination with oil, either mineral oil or fish oil, is more difficult to remove, especially when applied in the late cover sprays. In consequence, the use of the nicotine-oil combination is being recommended, to replace application of lead arsenate late in the season, i. e. after July 25. This combination consists of one gallon of summer oil and nicotine sulfate used at the rate of ¾ pint to 100 gallons. Careful checks at Wenatchee during the past season show that this combination is equal to lead arsenate used at the rate of three pounds to 100 gallons of water.

Because of an insufficient supply of nicotine sulfate in 1930, this material was probably not nearly as widely used as it would have been had this material been available. Many growers are already using it and indications point to a much greater use of the oil-nicotine combi-

nation in 1931. Foliage treated with cover sprays, including the oil-lead combination together with a nicotine-oil, is particularly free from damage by red spiders, leafhoppers, and aphis. Freedom from injury of this kind is sometimes reflected in an increased size of apples produced.

That the Washington fruit grower cannot afford to let up to the slightest degree in his efforts to control the codling moth is illustrated in an experience at Wenatchee last summer. A single tree used in an experiment where overhead irrigation was in use was left unsprayed during the entire season. In spite of the fact that the apples were thinned from time to time during the season and that surrounding trees were adequately sprayed, the fruit on this tree was 75 per cent wormy. Again, the hold-over from such trees in another season is likely to remain a wormy spot in the orchard for another year regardless of a spraying program. It is necessary to use extreme measures to reduce infestation in the first place, and is further necessary to make sure that this reduction is held in order to prevent a recurrence of that condition of affairs.

AN EFFORT IN PRACTICAL CONTROL OF CODLING MOTH IN A MISSOURI APPLE DISTRICT

By GEO. D. JONES, *Assistant Entomologist, Missouri Agricultural Experiment Station*

ABSTRACT

This paper reviews the results of three months cooperative effort against the codling moth (*Carpocapsa pomonella*) in an infested district near Waverly, Missouri. This cooperation existed between a group of growers whose properties involved a total of over 1,000 acres of bearing apple trees, the Missouri College of Agriculture, and the Missouri Pacific Railway Company. In the season of 1928, the year previous to this effort, the percentage of infested fruit in the district from codling moth at picking time was fairly high. In 1929 at the end of the picking season, in spite of a rainy, cold season, which made it impossible to keep a cover of spray material on the fruit and foliage, the growers were agreed that they harvested an increased percentage of clean fruit and that they had been saved the expense of one spray.

This experimental effort, conducted in a practical way against the codling moth, was cooperative in nature. It consisted of a cooperation between the apple growers of Waverly, Missouri, the Missouri Agriculture Experiment Station, and the Missouri Pacific Railway. According to the terms of the agreement, the Experiment Station was to furnish the man who would collect the specimens, breed out the pest, and forecast the insect's activity so that the growers could time their sprays accordingly. He was to give such aid, as was possible regarding

spraying and materials to use. This cooperation was to cover a period of one season from April 20th to July 20th.

The occasion for this cooperation was the inability on the part of the growers to protect their fruit against codling moth injury.

OUTLAY OF EXPERIMENTAL STUDY:—As much material was kept under outside conditions as was practical. The breeding cages were placed under the trees in such a manner as to parallel outside orchard conditions. A thermometer was used to record temperatures. The material used was collected from tree trunks and barrels stored in packing sheds. A few specimens were taken from barrels and sorting tables found in an orchard.

A shed used for the packing and storage of apples was used as an insectary. Some 200 baskets provided the source of moths for study under inside conditions.

SPRAYING SCHEDULE AND METHOD OF APPLICATION:—The unusual cold, rainy weather made spraying a difficult task. During the entire spraying schedule for the first brood, it was almost impossible to maintain a good coverage on fruit and leaves. After this period of rainy weather a good coverage was more easily maintained.

Most of the growers abandoned the cluster bud spray because of rain. More success was had in putting on a good calyx spray. The insecticide used, was lead arsenate applied at blossom fall, and during the periods of entry by larvae of the first, and of the second broods.

The growers employed many different methods in applying the spray; the methods used were adapted to the conditions under which they had to work, in so far as possible. Some made applications entirely from the ground, and others from the ground, and from the tank and tower. Some used spray guns and others used an ordinary rod. It was found that some growers were more successful than others in the handling of the spray material. In general the cleanest fruit occurred in the lower two-thirds of the tree. Several growers grew as clean fruit in the top as in any other part of the tree. This was very evident in a number of orchards.

Timing of Application:—The timing of the calyx application was easy because the development of the blossoms on the trees determined the time of application. The time of application for the first cover spray for the first brood larvae was estimated on the basis of the emergence of the moth from the overwintering generation of larvae. When approximately 40% of the moths had emerged, the application of the first cover spray was attempted. Partial repetitions of this cover spray were put on because of heavy rains. Spraying did not cease as the emergence con-

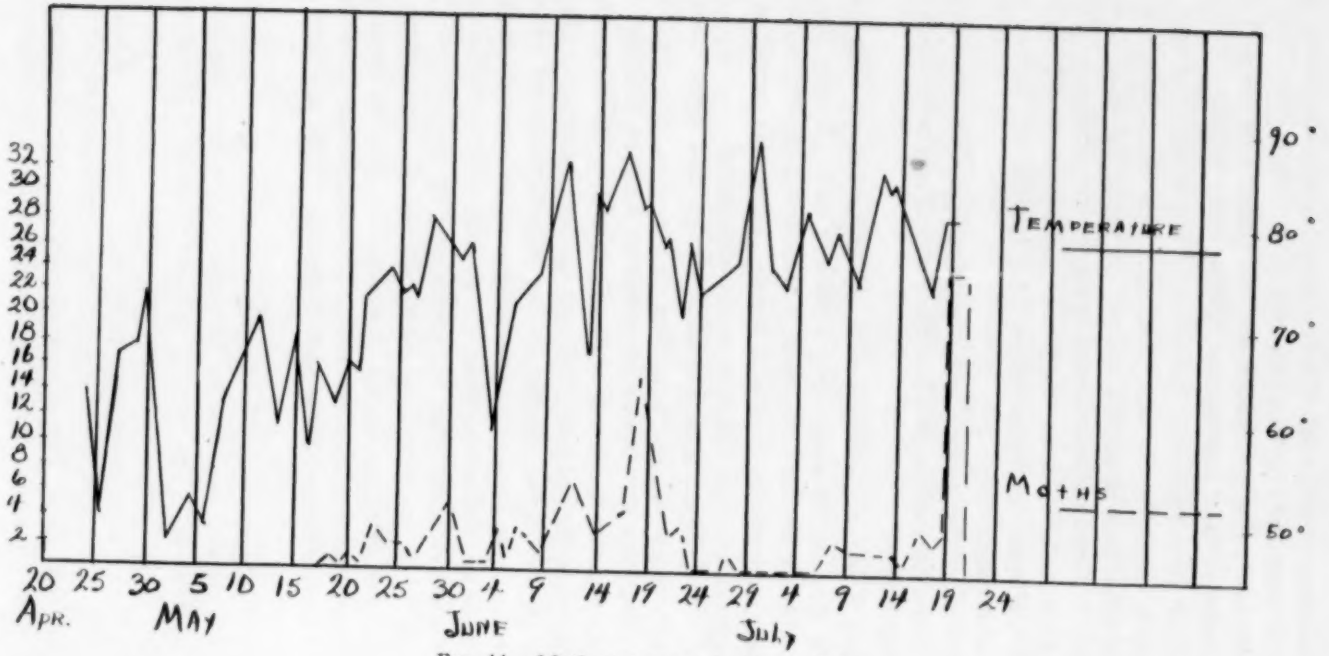

FIG. 44.—Moth emergence, inside condition.

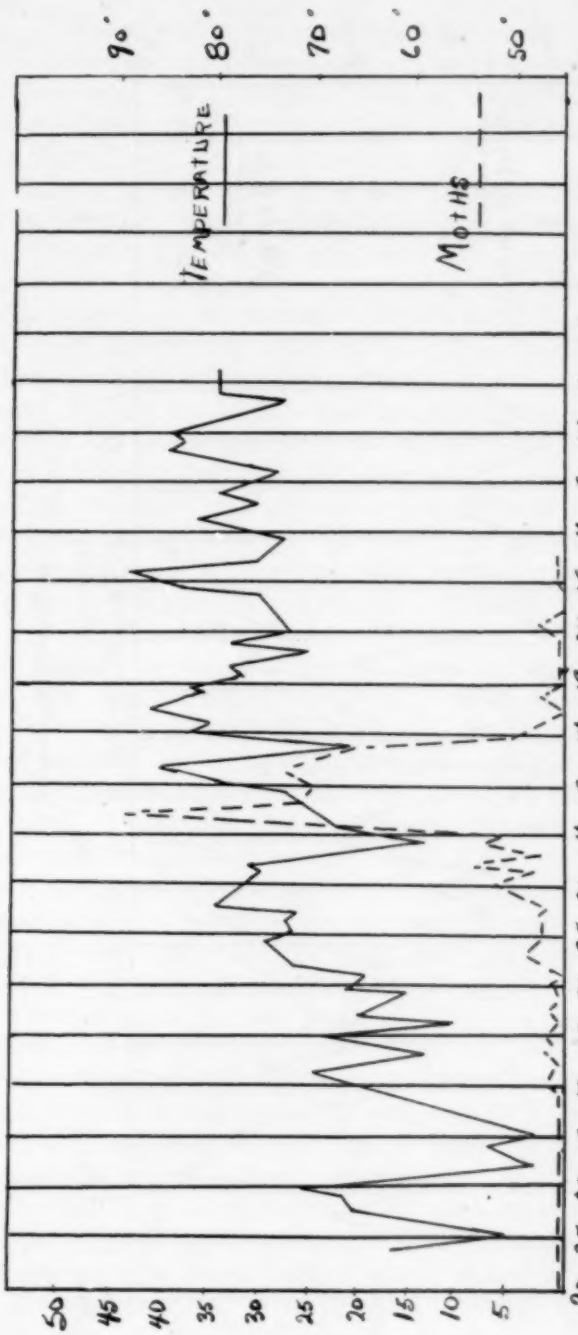

FIG. 45.—Moth emergence, outside conditions.

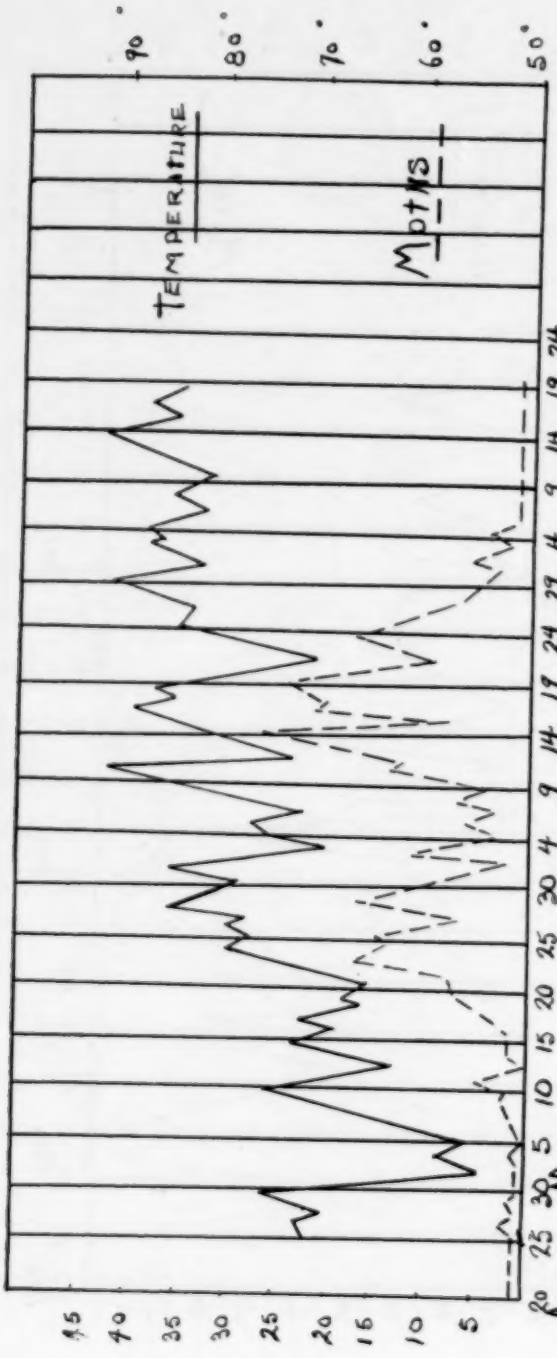

FIG. 46.—Daily bait record.

tinued. The time for the first cover spray for the second brood larvae was determined as the date when approximately one-third of the moths of the first brood had emerged. Some of the growers made partial repetitions for the maintenance of the coating when rain followed a day of spraying.

The growers were notified of the date when they should apply the spray and when to expect the first appearance of worms. A bulletin board was put in a prominent place where the growers could observe daily activity. Some growers in neighboring districts were telephoned of the dates to spray, others were notified by mail.

Results:—This effort was conducted for a three months period and the results are consequently only a partial record. However, the results are indicative of what can be done and accomplished in a practical way.

In the accompanying Figs. 44, 45 are shown the emergence of moths under outside conditions and in the insectary. It is evident, after comparing Figs. 45 and 46 with the bait record shown in Fig. 46, that the insectary material more closely paralleled the bait record than did the outside material. This perhaps was due to the outside cages becoming damp, and since they were under the trees, they did not dry out as readily as they should have. The insectary material seemed to indicate that the first brood eggs would begin hatching after May 25th. On the 27th of May the first codling moth larvae was noticed to have entered the side of an apple in an orchard near by. For the summer brood of codling moth, the bait records again checked with the insectary bred material, and the date for beginning the spray against the second brood was set as July 15th. Most of the growers began spraying for the codling moth when the date was once set for greatest activity. The station work came to a close before final counts could be made, but in a meeting after the season was over, the growers agreed that the effort had been a success since they had a decided reduction in the amount of codling moth injury and had been saved the cost of one spray, as compared to the preceding year.

Some Indications from the Season's Work as Conducted:—Probably the most outstanding indication relating to future work on this project is the fact that the codling moth's life cycle may be studied in a practical way, and a better control may be expected when the insect's activity is known and the spraying is timed accordingly.

Another indication, which was impressed on the growers, was the fact, that where orchard sanitation was not practiced, they could expect a great amount of injury near packing sheds, or near any material used during the season, and left in the orchard in or under which the overwintering larva had found protection.

CARPENTER WORM INJURY TO ASH IN NORTH DAKOTA

By J. A. MUNRO, *Entomologist, North Dakota Experiment Station, Fargo, North Dakota*[1]

ABSTRACT

The carpenter worm (*Prionoxystus robiniae* Peck) is causing serious injury to the green ash (*Fraxinus lanciolata*) in the Fargo vicinity. Other species of trees in the vicinity of known infestations do not appear to be attacked. This paper includes notes on the life habits and control of the insect. The Arkansas kingbird and the common kingbird appear to be valuable as agents of natural control. Woodpeckers are apparently unable to capture the borers. Cutting down and burning of infested trees during winter is recommended as a satisfactory control.

The carpenter worm (*Prionoxystus robiniae* Peck) is proving to be a serious pest of the green ash (*Fraxinus lanciolata*) in the vicinity of Fargo, Cass county, North Dakota. It is not known when this insect became established here but it is probable that it has been prevalent for a number of years.

Although other trees commonly listed as hosts, including maple, elm, poplar, and willow, grow in the vicinity of the already known infestations, only the green ash has appeared to be attacked.

This condition is well illustrated in a 35 year old demonstration wood lot located near Fargo. The wood lot comprises two acres and contains a mixture of ash interspersed with maple, elm, box elder, poplar, and willow. Approximately one-half of the trees are ash. A survey of this planting during the summer of 1930 showed nearly ninety per cent of the ash in this wood lot to be infested.

During the past spring the trunks of three of the infested trees were caged and observations made to determine the emergence dates of the adults. The cages were constructed of ordinary screen wire tacked to strips of wood which were nailed to the tree trunks. Four strips of wood, spaced at regular intervals and placed vertically around the trunk, were used to each cage. This provision held the screen far enough from the bark of the tree to allow the adults to emerge unhampered. The cages were closed above and below to prevent the escape of the moths.

On June 6th a female moth was captured in one of the cages; this was the earliest emergence date recorded for the season. During the days that followed, male and female moths were captured in all three cages. A total of 17 moths were captured in the cages from June 6th to June 14th. No further captures were had in the cages after June 14th.

[1]Appreciation is expressed to Dr. Wm. Schaus, Bureau of Entomology, for identification of specimens, and to Mr. W. G. Bruce, Bureau of Entomology, who assisted the writer in making observations.

Ash trees in the vicinity of the caged trees yielded many moths. During the period of moth flight, which extended through the greater part of June and the first few days of July, it was almost a daily occurrence to collect from a few to upwards of twenty specimens from the trees near-by. The flight period coincided with that in New York state as given by Felt (1).

During the fore part of the flight period many male moths were attracted to the outside of the cages, evidently by the trapped females within. The males flew most actively in the evening, beginning about sunset, and were attracted in numbers varying from a few to upwards of about ten per cage.

In appearance the female moths were heavy-bodied, gray with lighter markings, and had a wing expanse of about three inches. The males were lighter-bodied, slightly darker in color, with a wing expanse of about 2 1 /8 inches. A prominent area of orange color on each hind wing further characterized the males. The female moths appeared rather clumsy in their movements and seldom moved any great distance on the tree trunks unless they were disturbed. So far as could be determined, they normally remained to lay eggs on the same trees from which they emerged. On the other hand, the males flew most actively and probably travelled considerable distances in an evening.

Transformation of the pupa to the adult stage was observed to begin about sunset. Beginning then, the large brown pupa appeared at the entrance of the exit hole and by a series of muscular movements emerged so that about one-third of it (including the head and thorax) protruded from the tree. Here it apparently anchored itself and in a few minutes the moth escaped through a dorsal slit of the thorax and head part of the pupal case. The case remained in the wood and the adult usually crawled a few inches along the bark before resting to allow its wings to develop and harden. In the course of fifteen to twenty minutes from the time of emerging from the tree, it appeared to have completed its transformation. In several instances mating and fertilization were observed to occur the same evening as transformation.

Oviposition usually began within a day or two following fertilization and, of a total of eight moths observed, all had completed egg laying within two days from the time they had begun. The number of eggs laid by each of two females were counted and numbered 218 and 257 eggs, respectively.

The eggs were rather oblong in shape, about one-tenth inch in length, grayish and covered with an adhesive substance that caused them to

adhere fairly well to the bark, and were normally placed in small groups along crevices and depressions in the bark.

Hatching of the eggs was first observed to begin on June 25th and extended over a period of about one week. The newly hatched larvae appeared reddish-brown in color, with a dark colored head, and measured about one-fourth inch in length. After feeding for a short while on the empty egg shells, the larvae became most active and began migrating along the bark in various directions. Many of them were observed to enter tunnels already made in the wood by older larvae, while others entered by cutting holes in the bark. Some were observed to leave the trees and go to the ground. Whether or not the latter migrated to other trees was not determined.

Some of the characteristics of the young larvae resembled very closely those of the older larvae. Both young and old larvae appeared most active and could travel forward or backward without apparent difficulty. Examination of the larvae in various stages showed that their prolegs were equipped with numerous minute curved spines arranged so that the worm might readily grasp the surface for any direction which it wished to travel. Except for size and color, the young larvae resembled the older ones in appearance. The mature larva was mottled rose and white in color with a dark head and prominent thoracic shield, was stout-bodied, and attained a length of about two and one-half inches.

When the young larva had entered the bark to a depth of about one-fourth inch it reversed its position, so that its head-end faced outwards, and hastily closed the entrance with particles of chewings held in place by a loose silken web which it constructed; with this completed it resumed its boring into the wood.

As might be expected, the carpenter worm injury to the ash, in this and other plantings in the Fargo vicinity, has gradually assumed serious proportions. Trees that were lightly infested a few years ago but otherwise appeared healthy are now badly scarred and deformed, due to the ravages of this pest. The tunnels and borings made by the worms have so weakened and undermined the trees that a number of them have been broken over during windstorms. This injury, unless checked, extends over a period of years to the individual trees. The larvae require approximately three years for development, as pointed out by Burke (2), during which time the wood of the trees is much damaged by them; the infested trees being subject to re-infestation are practically due for destruction.

Of the various control measures suggested, it would appear that the systematic cutting down and burning of infested trees during the fall

and winter months is the most practicable to recommend for infested wood lots as obtaining in this section of the Great Plains area. As the larvae frequently invade the lower portion of the trees, this method should also include the destruction of the stumps before the emergence period of the adults. The removal of infested trees from time to time, would permit the planting of evergreens or other species of trees, not susceptible to carpenter worm injury, to take their places. In the case of shade trees or valuable trees, which the owners may not wish to destroy, these may be saved if treated in time, either by the use of carbon bisulfide introduced to the tunnels, as suggested by Childs (3), or the screening of individual trees and destruction of the moths as suggested by Burke.

Certain birds in the vicinity of these plantings are probably a greater factor in the suppression of the carpenter worm than is often realized. Of the various birds which were observed to capture these insects, the Arkansas kingbird proved to be the most important and the common kingbird appeared to rank second. A number of these birds were in the neighborhood and for a period of a week to ten days appeared to feed largely on this pest. On several occasions these birds were observed to capture living pupae as they emerged from exit holes in the wood, and it was a common occurrence to see them capture the moths.

Examination of the crop contents of three Arkansas kingbirds, taken during the period of moth emergence, revealed the presence of only pupae and moth remains. No examination was made of the crop contents of other species of birds.

A few species of woodpeckers, including the downy woodpecker, hairy woodpecker, and flicker, which were in the vicinity apparently did not help to control the pest probably because the worms entered deeply in the wood and when disturbed could escape beyond reach in their tunnels.

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APPLE MAGGOT STUDIES IN 1930

By P. J. CHAPMAN[1], *Geneva, N. Y.*

ABSTRACT

Three major phases of the apple maggot (*Rhagoletis pomonella*) problem are considered with the object of meeting requirements imposed by the 1930 restrictions governing apples for export. These studies include (1) spraying with arsenate of lead to poison the flies, (2) spray residue, and (3) sterilization of fruit after harvest. Cage records indicate that the insects initial and maximum emergence is about one week later in the Lake Champlain area of New York as compared with the Hudson River Valley. Applications of arsenate of lead about July 5 and July 20 appeared to give good control this season, with an indication that an additional treatment early in August was necessary in certain Lake Champlain Valley orchards. Tests involving 100 bushels of apples and seven varieties show that cold storage at 30–33°F. of a month's duration will kill a very high percentage of larvae in harvested fruit.

In 1930, the apple maggot, *Rhagoletis pomonella* (Walsh), assumed a distinctly new importance in Northeastern United States because of stringent restrictions directed against it by the British Government. Concern on this account, in New York, is confined primarily to the Hudson River Valley fruit district for the reason that a large volume of fruit is customarily exported from this region, and apple maggot, as a pest of commercial orchards, is essentially limited to this territory and a small district in Northern New York along Lake Champlain. This pest is not often troublesome in Western New York, a condition believed to be due largely to the necessity of applying sprays late in the summer for codling moth and apple scab, both of which are more serious in the western district.

To meet the new conditions governing the exportation of apples, our point of view on what constitutes control has had to be changed. Fruit intended for the British markets must now be free from live larvae and even *injury from larvae*. These requirements would be much easier to meet if infested fruits could be readily recognized and culled out at harvest. So inconspicuous are the egg-punctures, however, that many escape notice unless every apple is closely scrutinized; and under commercial conditions this would be too time consuming and too uncertain of results. It would appear, therefore, that emphasis should be placed on increasing the efficiency of control measures now in use and on develop-

[1]The writer is indebted to the following for their assistance in these studies: P. J. Parrott, A. B. Burrell, F. G. Mundinger, Oscar Hammer, Laurence Woodruff, and the Farm Bureaus in Dutchess, Ulster, Orange, Columbia, Greene, Saratoga, Warren, Essex, and Clinton counties of New York.

ing certain new practices to fulfill export requirements. With this viewpoint in mind, we have considered the following phases:

(1) The determination of how much dependence can be placed in the use of arsenate of lead to poison the apple-maggot flies during their preoviposition period.

(2) In carrying out a plan of keeping arsenicals on the trees during the emergence period of the flies, which usually extends from late June to the middle of August, a natural additional problem is that of spray residues. Since this subject has already been discussed in another paper it will not be elaborated on here other than to call attention to its place when the broad aspects of the apple maggot problem are considered. Our immediate concern has been: an inquiry into the amount of arsenic persisting at harvest under a thoro schedule of spraying for the maggot; the nature of spray and other foreign deposits on fruit in New York, and commercial methods for their removal. We have also considered in this connection the possibility of finding a substitute for arsenate of lead in these later sprays.

(3) The search for practical methods for the sterilization of fruit after harvest. The thought in mind here was that a grower might reduce apple maggot to a low point in his crop by means of careful spraying or otherwise, and then subject it to a sterilization process to insure absolute freedom from live larvae.

Aside from these major considerations, studies concerning control are in progress on parasites, chemical soil treatments, attrahents, and such cultural practices as the picking up of "drops".

Emergence of Flies. Eighty-six cages, each covering 40 sq. ft. of earth, were used to determine the emergence period of the flies. These were well distributed thru the infested area, forming a more or less continuous chain about 300 miles in length, along the eastern boundary of the state. With very few exceptions sites for the cages were selected after the middle of June, 1930. (This is not an example of procrastination on our part but an effort to make the most of an eleventh-hour emergency.) On some of these locations we were evidently not well advised since certain cages yielded few or no flies. Fortunately, however, fair numbers were recovered from other cages. Figure 47 gives the composite yield of 2666 flies taken from 19 cages in the vicinity of Peru, N.Y., in the Champlain Valley and 1419 flies from 21 selected cages lying between Hudson and New City, N. Y., in the Hudson River Valley. The timing of treatments in our experiments and those of the fruit growers generally were based on these data.

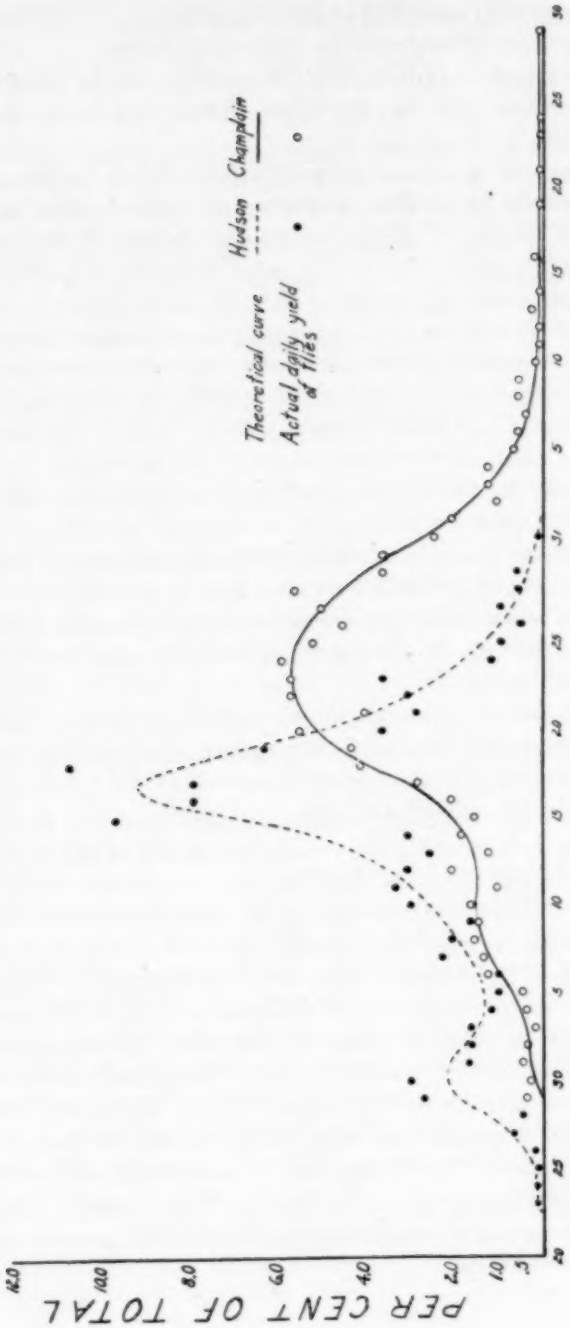

FIG. 47.—A comparison of emergence of apple maggot flies in the Hudson River and Lake Champlain fruit districts of New York in 1930.

SPRAYING EXPERIMENTS. Twelve orchards were treated by us personally as part of the experimental program. These were not elaborate tests, their primary purpose being to gain information on practical control measures with means readily accessible to the grower. In four orchards, for example, no other plan was followed than the thoro spraying of the planting at the times generally recommended to the growers. In others, comparisons were made between one, two, or three applications of arsenate of lead or a simple comparison of a standard schedule of arsenate of lead spraying against some other material.

In addition to information gained from these twelve experimental orchards, considerable light was thrown on actual conditions in the infested area from records taken in 115 commercial orchards. Another source of information drawn upon was the experience and general observation of fruit buyers, cold storage operators, and agricultural leaders. In view of this variety of values we believe we are justified in saying that satisfactory control was rather generally obtained this season thru the application of arsenate of lead early in July, followed by a second treatment about July 20. There is also an indication that an additional early August spray was necessary in severely infested orchards of the Champlain Valley.

Satisfactory control in the sense just used does not imply eradication, but rather a distinct subordination of injury as it affects the sale of the total crop. It is true that this may approach eradication in cases where the initial infestation was light. However, from several tests this season, we have the indication that more than one season's thoro spraying may be necessary before entirely satisfactory results will obtain in orchards where the maggot is firmly intrenched. In this connection attention should be called to the kind of orchard used in our 1930 tests. Naturally, plantings were sought where apple maggot was a definite problem. It is a significant fact that our quest almost invariably led us to plantings which in a broad sense would be considered marginal farms. Either no attempt had been made to control apple maggot, and often other pests as well, or where July treatments had been made—and this condition was seldom met with outside the Champlain Valley, where the maggot reaches its most serious proportions—failure to control could be readily traced to ineffective equipment or ill-timed, indifferent treatments. Certainly, this is strong circumstantial evidence as to the efficacy of spraying as a control measure. While the investigator is frequently forced to use orchards of this type, it should be borne in mind that they are in a sense abnormal and results may not be interpreted too literally.

Bearing on the foregoing discussion are salient details of several 1930 orchard experiments:

1. *Taber orchard, Milton, N. Y.* The actual infestation in this orchard in 1929 was approximately 10%, as determined by Mundinger.[2] Prior to 1926, and in 1928 when spraying was poorly done, apple maggot had been very troublesome in the Jonathan and Wealthy varieties. With the object of determining how effective a single treatment would be under conditions which are rather typical of many commercial plantings in this area, a spray was applied July 10. The following is a record of the total crop of two Jonathan trees in this orchard:

Total Number of Fruits	Number Infested	Per cent Infested
4086	52	1.27

2. *Place orchard, Peru, N. Y.* Since 1914 this planting of 180 trees, of which 80 are of the Snow or Fameuse variety, had suffered serious injury from the maggot. Every year, including 1929, the Snow trees had been essentially 100 per cent infested. The grower had made some half-hearted efforts to spray, but apparently this had not checked the annual depredations of the pest. In 1930, three sprays were applied July 1, July 21, and August 7. The formula was: Arsenate of lead 2½ pounds, lime-sulfur 2½ gallons, water to make 100 gallons. The trees were mature but the bearing surface was small since only 5½ gallons of spray per tree was necessary for a good coverage. (This, however, was about four times as much spray as customarily applied by the grower.) The condition of the crop at harvest is indicated by the following counts:

Variety	No. Trees Counted	Total Fruits	Number Infested	Egg Punctures per Infested Apple	Per Cent Infested
Snow	1	1148	44	1	3.8
Northern Spy	1	835	34	1	4.1

3. *Smith's and Downs' orchards, Peru, N. Y.*

These plantings are separated by a road; each is about six acres in size, contain many of the same varieties, and apple maggot has long been a serious problem in both orchards. In 1929 no apples were sold from either orchard because of the pest. Of the two, one would be inclined to believe that the maggot would be more difficult to control in the Smith orchard because of protection from a woods, the closer planting, and generally thicker growth. For these reasons Smith's orchard was selected to receive three sprays and Downs' two. Dates of application were:

[2]Mundinger, F. G. Jour. Econ. Ent. **23**:767. 1930.

July 5, July 22, and (for Smith orchard only) August 7. The spray formula was the same as for the Place experiment. At harvest the total crop of representative Snow trees was examined in each planting.

Treatment	No. Trees Counted	Total Fruit	Number Infested	Egg Punctures per Infested Apple	Per Cent Infested
3 applications	3	3600	334	1.5	9.27
2 applications	2	2248	673	2.0	29.9

SUBSTITUTES FOR ARSENATE OF LEAD. Because of its possible bearing on the spray residue phase of the study several materials were substituted for arsenate of lead in the apple maggot treatments. In measuring the value of substitutes for standard poisons one must not lose sight of the entire range of functions they must perform before they can be adopted as true substitutes. In New York, for example, there would be little place for an apple insecticide which would control apple maggot but be ineffective against codling moth. Prominent among possible substitutes for arsenate of lead were the copper compounds because of their use against the Mediterranean fruit fly. The field tests of copper carbonate and sweetening were inconclusive against apple maggot because of an inadequate check.[3] However, the codling moth record taken on the total crop of four Snow trees in this experiment is of interest:

Treatment	Trees Counted	Total Fruit Counted	Per Cent Infested Apple Maggot	Fruit Infested with Codling Moth	
				Number	Per Cent
Arsenate of lead	2	8164	0.28	730	8.9
Copper carbonate	2	9536	1.41	3265	34.2

STERILIZATION EXPERIMENTS. Early in our consideration of possible means for the destruction of apple maggot larvae in picked fruit came the thought of cold storage. In the season just passed we have included in our cold storage experiments approximately 100 bushels of variously infested fruit representing seven varieties (Red Astrachan, Sweet Bough, Twenty Ounce, McIntosh, Detroit Red, Jonathan and Ben Davis). As a result of these studies we may conclude: that storage of infested fruit at temperatures customarily maintained in commercial fruit storage, namely 30–33°F., will kill apple-maggot larvae; with a definite indication that individuals succumb after 15–20 days of uninterrupted storage; and in our tests 99 per cent mortality or higher is reached with 30 days' storage. It is planned to give details of these experiments in a future paper.

[3]Formula: Copper carbonate 4 pounds, brown sugar 12½ pounds, molasses 2½ gallons, water to make 100 gallons. Applied twice as a spray using 12½ gallons of the diluted mixture per tree. Considerable leaf injury and subsequent dropping of eaves occurred.

CONTROLLING THE FRUIT TREE LEAF-ROLLER (*ARCHIPS ARGYROSPILA*) WITH OIL EMULSIONS

By G. S. TOLLES, *Department of Entomology, Michigan State College*

ABSTRACT

Several oil sprays were tested in the laboratory during the early spring of 1930 to determine their efficiency as ovicides in leaf-roller control. Dendrol 8%, Kleenup 8%, Diamond Paraffin oil, emulsified with Kayso, using 6% of actual oil, Sunoco spray oil 8%, and Scalecide 8% were tested. All of these were applied during the *late dormant* period, save Scalecide, which was applied during the delayed dormant period. All of these sprays gave satisfactory control except Scalecide.

Orchard tests following the laboratory tests, in which Dendrol 8%, Kleenup 8%, Diamond Paraffin 6%, and Scalecide 8% were tested, gave practically the same results as the laboratory tests.

The fruit tree leaf-roller, *Archips argyrospila* Walk., was first reported in Michigan in 1916. During the past several years, it has been increasing in numbers and spreading, until at the present time it is to be found throughout the state. The use of oil sprays has been recommended for the control of this pest, but the results in the past have been varied and often disappointing.

During the spring of 1929, tests were made and several spray oils applied in an attempt to secure a satisfactory control of the pest. Due to adverse weather conditions, very poor coverage was obtained, resulting in unsatisfactory control, the loss amounting to at least 50% in the test blocks, as determined at picking time.

LABORATORY TESTS. During the winter of 1930, it was decided to test a number of spray oil emulsions in the laboratory for their efficiency as ovicides in leaf-roller control. Accordingly, several hundred branches, from 24 to 30 inches long, each bearing a number of egg masses, were selected. These branches were placed in large crocks, containing wet sphagnum, and after standing for some little time in order that they might develop almost up to the hatching condition, they were sprayed with an assortment of oil sprays, using the various strengths recommended by the manufacturers. Before the spray was applied, the buds on the twigs were allowed to develop nearly to the point where they would show green. Scalecide, on the other hand, was applied at the delayed dormant period, because the manufacturers recommend its use at that time. The sprays were applied with a hand pump, and many separate lots of these twigs were subsequently washed with the hose in an attempt to find out just what effect rain would have when it followed the application of the spray. Various lots of sprayed branches were washed at different intervals after spraying. This washing consisted of drench-

ing them from all sides with a pressure hose for about ten minutes. The intervals at which washing was carried on are given for each lot in the accompanying table. It is interesting to note that the washing had little, if any apparent effect on the efficiency or permanence of the spray. In the following table, the number of eggs present is used, rather than the number of egg masses. It was found that the average number of eggs in a mass was about sixty.

TABLE 1. LABORATORY TESTS OF OIL SPRAYS FOR LEAF-ROLLER EGG MASSES

Oil Used	Time of Washing	No. of Eggs	Eggs Hatched	Per Cent of eggs not Hatched
Dendrol 8%	After 4 hrs.	600	37	94.
"	" 10 "	600	11	98.
"	" 24 "	600	48	92.
"	" 48 "	600	2	99.
"	Unwashed	600	0	100.
"	"	6600	5	99.9
"	After 24 hrs.	6720	51	99.3
Sunoco 8%	" 4 "	600	0	100.
"	" 10 "	600	0	100.
"	" 24 "	600	14	98.
"	" 48 "	600	7	99.
Kleenup 8%	Unwashed	5640	0	100.
"	After 24 hrs.	2840	0	100.
Diamond Paraffin 6%	" 4 "	3000	307	99.
"	" 48 "	3000	0	100.
Scalecide 8%	" 10 "	600	248	59.
"	" 24 "	600	168	72.
"	" 48 "	600	225	63.
"	" 24 "	3420	3300	4.
"	Unwashed	2840	2400	16.
Check	"	3540	3537	0.08

The percentage of eggs which failed to hatch in the plats referred to in the above table, shows very good control in most instances, except in the case of Scalecide, which shows considerable variation and is uniformly low.

During the progress of the laboratory tests, many small larvae were observed suspended on silken threads. These larvae are regularly whipped about by the slightest breeze, often becoming attached to other branches, and sometimes landing on other plants in the vicinity. This would indicate a method by which the young larvae may be spread. It was also found that egg masses, where one or two eggs had already hatched, could be readily killed at this point, and the rest of the eggs prevented from hatching, by the application of an oil spray.

Following the laboratory tests just described, a series of orchard tests was made.

ORCHARD TESTS. Four spraying oils were selected for field tests in an orchard near Ludington. They were: Kleenup, used at the rate of 8%, Dendrol dormant spray oil, used at the rate of 8%, Scalecide, used at

the rate of 8%, and Diamond Paraffin oil, emulsified cold with Kayso, used at the rate of 6% of actual oil in the spray mixture. These sprays were applied with a high-powered spraying machine, using about 300 pounds pressure. All of these sprays were applied at the *late dormant* period, that is, just before green showed in the buds, with the exception of Scalecide, which was applied at the delayed dormant period.

A block of sixty-five large apple trees was selected in the corner of a large orchard for field tests during the spring of 1930. This block of trees was heavily infested with leaf-roller, and had lost about 50% of its crop during the previous season, because of their ravages. The trees had been pruned and the brush and small twigs very carefully picked up and burned. The destruction of prunings is imperative in order to prevent larvae from hatching and gaining access to the tree by crawling up weeds and being blown to lower branches, or by climbing up the main trunk. Egg masses were tagged in each plat, and later checked to ascertain the percentage of hatch.

TABLE 2. FIELD TESTS SHOWING OVICIDAL EFFECT OF OIL SPRAYS

Spray Used	No. of Eggs	Eggs Hatched	Per Cent of Eggs not Hatched
Scalecide 8%	3000	2969	2.0
Dendrol 8%	3000	142	95.3
Kleenup 8%	3000	77	97.5
Diamond Paraffin 6%	3000	87	97.1
Check	3000	2975	0.8

The percentage of unhatched eggs in these plats would indicate a better control than was actually accomplished, when one considers the sprayed part of the orchard as a whole. A few very large trees showed fruit and foliage injury. On checking over these trees, it was found that failure to kill some of the eggs was undoubtedly due to failure to cover the egg masses in the tops of the trees. Aside from these few large trees, the control was very satisfactory, except where Scalecide was used.

No appreciable spray injury was noted on any of the trees in any of these plats.

The results noted were gained from tests carried on for one year only. The following points seem important in the fight to control the leaf-roller: The largest number of egg masses are to be found on the upper sides of the small branches, on two and three year-old wood. No doubt, if the infestation becomes more serious, larger limbs will also be found to carry many eggs. It is imperative that each egg mass be covered by the spray in order to obtain commercial control. This treatment requires the application of a good oil of a proper strength at a *late dormant* period, (just before the buds show green) after danger of freezing is past.

STUDIES WITH HYDRATED FERRIC OXIDE AS CORRECTIVE AND STICKER FOR LEAD ARSENATE AND NICOTINE TANNATE[1]

By JOSEPH M. GINSBURG, Ph.D., *Biochemist in Entomology*, and RUSSELL F. MANN, *New Jersey Agricultural Experiment Station*

ABSTRACT

Tests with several grades of hydrated ferric oxide were carried out for the purpose of determining their value as stickers and correctives for arsenical injury on apple foliage. Hydrated ferric oxide mixed with lead arsenate increased the adhesive properties of the latter to apple foliage and prevented arsenical injury. Hydrated ferric oxide by itself does not injure apple and peach foliage. A mixture of hydrated ferric oxide and skimmilk was found to possess good spreading and sticking qualities for insecticides and fungicides.

The object of this investigation was to study the possible application of certain grades of ferric oxide as correctives for arsenical injury in general and as stickers for lead arsenate and other insecticides. Hydrated lime, usually used as corrective with lead arsenate, has its drawbacks. First, it is not an efficient sticker; second, if used at all, it must be applied in large quantities otherwise, soluble $CaHAsO_4$ will be formed (2, 5) and more arsenical injury will result with it than without it.

Hydrated ferric oxide[2] does not form soluble arsenical compounds when mixed with lead arsenate in smaller or larger quantities. On the contrary, by virtue of its high adsorptive properties for arsenious oxide (1) it may remove soluble arsenic from the spray mixture or leaf surfaces. Furthermore, ferric oxide possesses great adhesion to foliage as shown (7) in some previous experiments. It was, therefore, thought that the ferric oxide particles should, while adhering to the leaf surface also retain particles of other compounds, such as lead arsenate or nicotine tannate with which they have been intimately mixed previous to application.

EXPERIMENTAL. Experiments conducted during 1926 and 1927 (7) have shown that:

1. Ferric oxide, in concentrations of 4 lbs. and 8 lbs. to 50 gallons of water does not injure apple or peach foliage.

2. Ferric oxide when intimately mixed with lead arsenate reduces or entirely eliminates arsenical injury to apple foliage by either adsorbing the soluble arsenic formed or converting it into insoluble ferric arsenate.

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

[2]The various grades of hydrated ferric oxide were obtained from Binney and Smith Company, 41 East 42nd Street, N. Y.

3. The spray mixture containing ferric oxide remained on foliage considerably longer than did the spray containing no ferric oxide. This fact is of importance to the fruit grower. The longer the insecticide remains on foliage, the more complete is the control of insects.

EXPERIMENTS IN 1929, *Tests on Apple Trees*. During the summer of 1929 large blocks of apple trees (2 rows of 20 to 30 trees each) located in L. Collins' Orchard, Morristown, N. J. were sprayed several times successively with lead arsenate containing ferric oxide. The composition of the chemicals used in the various spray mixtures are given in Table 1. Thruout these experiments "Mapico Yellow" was used, which is a very fine grade of hydrated ferric oxide, of yellow color. A total of three sprays were applied between May 28 and June 19. Each block consisted of the following varieties: Staymen, Wealthy, Jonathan, Starr, and Rome Beauty.

TABLE 1. COMPOSITION OF SPRAYS ON SIX BLOCKS OF APPLE TREES IN 1929.

Block No.	Composition of Spray on West Side	Composition of Spray on East Side	Injury Observed after Three Sprayings
I.	$PbHAsO_4$ paste 25 lbs. Flour 12 lbs. Water 300 gals.	Same as on West Side	None
II.	$PbHAsO_4$ paste 25 lbs. Fe_2O_3 6 lbs. Kayso 3 lbs. Water 300 gals.	$PbHAsO_4$ paste 25 lbs. Fe_2O_3 12 lbs. Kayso 3 lbs. Water 300 gals.	None
III.	$PbHAsO_4$ paste 25 lbs. Colloidal sulfur 12 lbs. Kayso 6 lbs. Water 300 gals.	Same as on West Side	None
IV.	$PbHAsO_4$ paste 25 lbs. Lime-sulfur 1:70 Kayso 3 lbs. Water 300 gals.	Same as on West Side	Appreciable arsenical injury to foliage
V.	$PbHAsO_4$ paste 25 lbs. Lime-sulfur 1:70 Ferric Oxide 6 lbs. Kayso 3 lbs. Water 300 gals.	$PbHAsO_4$ paste 25 lbs. Lime-sulfur 1:70 Ferric Oxide 12 lbs. Kayso 3 lbs. Water 300 gals.	None
VI.	$PbHAsO_4$ paste 25 lbs. $Ca(OH)_2$ 24 lbs. Sulfur 48 lbs. Kayso 6 lbs. Water 300 gals.	Same as on West Side	None

No arsenical injury to foliage or fruit was observed where flour, lime, or ferric oxide were used as correctives. Appreciable arsenical injury, however, occurred in block IV where liquid lime-sulfur and lead arsenate were combined without corrective. On the other hand, in block V which received identically the same treatment as block IV, with the

exception that ferric oxide was added, no arsenical injury resulted. In other words, ferric oxide acted as a corrective for arsenical injury usually resulting from the combined spray of liquid lime-sulfur and lead arsenate.

Tests on Plum and Cherry Trees. Cherries and plums are often severely injured by curculio. The skin of these fruits is very smooth and the standard New Jersey Dry Mix Spray does not adhere sufficiently long to prevent curculio injury. Ferric oxide was, therefore, tested on these trees.

Two rows of plum trees, and two rows of sweet cherry trees were secured from Mr. L. Collins, Moorestown, N. J. and sprayed three times with the following mixture:

Lead arsenate	2 lbs.
Fe_2O_3	6 lbs.
Sulfur	8 lbs.
Skim milk	3 lbs.
Water	100 gallons

The first spray was applied on April 26, or immediately after petal fall; the second spray was applied on May 7; and the third spray on May 15.

No injury resulted from these sprays. This fact was important because plum and cherry foliage are highly susceptible to arsenical injury. On May 15, Dr. Headlee and myself examined the sprayed blocks and found that good curculio control was obtained.

Experiments on Nectarines. The nectarine is a very smooth-skinned peach and any spray mixture is readily washed off by the first rainfall.

On June 22, a row of 8 nectarine trees, secured from Prof. Blake in the College Orchard were sprayed with the following mixture:

Lead arsenate	1 lb.
Fe_2O_3	2 lbs.
Skim milk	1 lb.
Water	50 gallons

Appreciable rainfall took place on June 24.

Observations on June 25 have shown that most of the spray was washed off. Evidently ferric oxide possesses little adhesion to the smooth skin of this fruit. No arsenical injury resulted from this spray.

The yellow ferric oxide, while proving a good sticker and corrective was objected to by the orchardist on account of its color. When the spray was applied and for a considerable time after that the foliage appeared as if coated with a yellow paint. The contrast between the unusual conspicuous yellow color and the ordinary green color of foliage was too great not to be noticed. The visual effect of this artificial coloration was apparently not so pleasing to the human eye, judging from the

remarks and criticism passed by farmers and extension agents. In order to overcome this unpleasant appearance experiments were carried on to produce a ferric oxide which should possess a color comparable to that of apple foliage. Such a compound was prepared by the Binney and Smith Company and is now a commercial product under the name of "Mapico Green". When two parts of lead arsenate are mixed with one or more parts of this ferric oxide the entire mixture assumes a dark green to brownish color resembling that of old apple-leaves. Whenever a green colored arsenical spray is desired, the above mixture could be safely used.

EXPERIMENTS IN 1930. The adhesion of Fe_2O_3 to fruit and foliage of apple, peach, plum, and cherry trees has been demonstrated during the previous experiments. We were not well satisfied, however, with the spreading of the ferric oxide. Of course, for efficient insect control it is absolutely necessary that the spray mixture should spread uniformly over both surfaces of the leaf. Preliminary results have indicated that powdered skim milk may prove a cheap and efficient spreader. When Fe_2O_3 and powdered skim milk were intimately mixed in proportions of 1:1 by weight, the resultant mixture proved to be a good spreader for both, lead arsenate and sulfur. For the sake of abreviation, this product will be referred to from now on as "Ferro-Skim". During the last summer it has been tested on peach and apple foliage and was found to be compatible with both lead arsenate and sulfur. No injury resulted from three successive sprayings of "Ferro-Skim" mixed with lead arsenate and either dry sulfur or liquid lime-sulfur in dilutions of 1:40 and 1:70.

COMPLETE SPRAY MIXTURE. It is of advantage to the orchardist if all the ingredients necessary to control both, insects and fungous diseases could be mixed and stored in dry form without decomposition. The outstanding internal insecticide used now in orchards is lead arsenate, while the outstanding fungicide is sulfur. Hydrated lime is usually added as corrective. These chemicals are incompatible for storage. In presence of lime (5), the sulfur forms polisulfides which react readily with lead arsenate, producing soluble arsenic and lead sulfide. The longer it is stored the greater the danger of arsenical injury to foliage. For this reason the orchardist buys the ingredients separately and mixes them before spraying. On the other hand "Ferro-Skim" does not react with the lead arsenate, nor does the sulfur react with the lead arsenate in presence of ferric oxide. These three ingredients should therefore form a compatible spray mixture which could be safely stored.

Complete mixtures consisting of lead arsenate 12%; Ferro-Skim 24%; and sulfur 64% were prepared in the early part of 1930 and sprayed on

TABLE 3. EFFECT OF FERRIC OXIDE AND THE AMOUNT OF NICOTINE REMAINING ON APPLE FOLIAGE SPRAYED WITH NICOTINE TANNATE

Mgm. Nicotine per 1000 Square Inches of Leaf Surface

Test No.	Date Sprayed	Composition of Spray in 100 Gallon Tank	Soon After Spray was Applied Mgm. Nicotine	10 Days After Spraying Mgm. Nicotine	10 Days After Spraying % Nicotine	20 Days After Spraying Mgm. Nicotine	20 Days After Spraying % Nicotine	Rainfall
1 (Check)	7/12/30	Nicotine Tannate pure 2 lbs.	5.24	1.93	36.8	—	—	1.79
2	"	Nicotine Tannate pure 2 lbs.	4.44	4.21	94.8	—	—	"
		Ferric Oxide, green 5 lbs.						
3 (Check)	8/12/30	Nicotine Tannate, commercial 4 lbs.	6.27	2.28	36.4	0.91	14.30	2.88
4	"	Nicotine Tannate, commercial 4 lbs.	5.36	2.28	42.5	1.14	21.27	"
		Ferric Oxide, yellow 10 lbs.						
5	"	Nicotine Tannate, commercial 4 lbs.	5.36	2.56	47.8	0.95	17.72	"
		Ferric Oxide, green 10 lbs.						

peach and apple foliage. No injury resulted from the sprays. The samples thus prepared have been kept in storage since and have not shown any signs of decomposition.

FERRIC OXIDE INCREASES THE ADHESION OF NICOTINE TANNATE TO APPLE FOLIAGE. Nicotine tannate is a new internal insecticide developed recently in New Jersey (4) as a possible arsenical substitute. This insecticide has already shown its efficiency (3, 4) in controlling codling moth. It is deficient, however, in adhesive properties. Field tests were, therefore, carried out with mixtures of nicotine tannate and ferric oxide on apple trees and the amounts of nicotine remaining on foliage after rainfall were quantitatively determined. Leaf samples of measured areas were collected by the apparatus already mentioned above and the nicotine analyzed gravimetrically, (8) using the official methods. The amount of nicotine thus found was reported in mgm. per 1000 square inches of leaf surface. Two grades of nicotine tannate were used. One was substantially pure, prepared in our laboratory, and contained about 20% nicotine. The second one was a commercial preparation and contained only about 10% nicotine. Twice as much per spray tank was, therefore, used from the second sample than from the first in order to introduce approximately the same amount of actual nicotine in the spray mixture.

The results presented in Table 3 indicate that more nicotine remained on foliage when nicotine tannate was combined with ferric oxide than when nicotine tannate was used alone. The difference between the checks and combined mixtures were appreciable after 10 days and not so significant after 20 days. Of course, the increased amount of rainfall may explain these differences.

SUMMARY AND CONCLUSIONS

Experiments with several grades of hydrated ferric oxide were carried out with the purpose of determining their possible use as stickers and correctives for arsenical injury on apple foliage. Mixtures of ferric oxide with lead arsenate and sulfur were sprayed several times in succession on large blocks of apple, peach, cherry and plum trees. The effects of these sprays as stickers and correctives were then studied. Observations were also made on the effect of ferric oxide on the adhesion of nicotine tannate to apple foliage. A product, consisting of mixtures of ferric oxide and powdered skim milk, which was later designated as 'Ferro-Skim", was used as spreader, sticker, and corrective with lead arsenate and nicotine tannate. The following conclusions may be drawn:

1. Hydrated ferric oxide by itself does not exert any injurious influence on peach and apple foliage.

2. When hydrated ferric oxide is mixed with lead arsenate, more arsenic remains on apple foliage than when lime is used as corrective.

3. When hydrated ferric oxide is mixed with nicotine tannate, more nicotine remains on apple foliage than when nicotine tannate alone is used.

4. "Ferro-Skim" forms a sticker and spreader for insecticides and fungicides.

5. When "Ferro-Skim" is used as a corrective instead of lime, a combined fungicide and insecticide containing sulfur and lead arsenate can be prepared and stored without decomposition.

6. Hydrated ferric oxide acts as corrective for arsenical injury when mixed with lead arsenate or with lead arsenate and liquid lime sulfur.

Acknowledgment

The authors are indebted to Dr. T. J. Headlee for valuable advice given thruout the experiment; also to Mr. Weber for determining nicotine in the leaf samples. The authors also wish to express their gratitude to the Binney and Smith Company from New York for supplying the various grades of hydrated ferric oxide and "Ferro-Skim".

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PRELIMINARY NOTES ON THE CHEMISTRY OF CODLING MOTH BAITS

By J. R. EYER and HINMAN RHODES, *New Mexico State College of Agriculture*

ABSTRACT

Chemical analyses of codling moth (*Carpocapsa pomonella*) molasses baits during their periods of maximum attractiveness reveals their attrahent value to be most closely associated with certain changes in the decomposition of the sugars which precedes the formation of alcohol and acetic acid and is first evidenced by a decrease in the glucose content of the baits. These phenomena which are probably attended by the formation of esters, the exact composition of each of which is as yet undetermined, are of primary importance. The formation of alcohol and the evolution of gas are important secondary factors, while the production of high yeast populations and the conversion of alcohol into acetic acid are only slightly attractive or actually repellent. Under New Mexico conditions, where the average mean daily temperature for the period during which the Codling moth adults are most active (May 1 to September 30) is 73.5° Fahrenheit, the effectiveness of molasses baits is actually decreased by adding yeast in commercial form while on the other hand it is materially increased and the period of attractiveness prolonged by the addition of certain preservatives, particularly Benzoate of Soda which delays fermentation.

A number of commercial esters were tested and the following are listed in order of their attractiveness: Iso-butyl Phenyl Acetate, Geranyl Formate, Ethyl Oxy-hydrate, Diphenyl Oxide, Citronellal, Bromo Styrol, Methyl Cinnamate. Most of these materials when used alone were not as attractive as plain molasses baits, and their attractiveness seems to be associated with their chemical composition, boiling point and characteristic odor.

During the past three years investigations have been in progress at the New Mexico Agricultural Experiment Station to determine the value of attrahent baits as a supplementary measure in the Codling moth control program. Bait pails similar to those described by Peterson (1) and Frost (2) were used prior to 1929 and in 1930 a type somewhat similar to that described by Yetter (3, 4) was adopted. During the early period of the work fifteen different kinds of molasses, sugar and fruit juice baits were tested and it was found that baits consisting of cane syrup or malt syrup diluted with water at the rate of one to ten gave the largest and most consistent catches of moths. During the summer of 1928 the highest average daily catch per pan with cane syrup was 2.4 moths and in 1929 it was 1.2. The highest catch in any one trap during a single night was 9 moths. The malt syrup bait in 1929 averaged 1.2 moths per pan with 18 as the highest catch for a single night. Furthermore, it was observed that the most attractive period of these baits was during the early stages of fermentation and that cane syrup (Brer Rabbit brand) apparently fermented more slowly than did malt syrup (Diamalt brand) and was attractive over a longer time. The addition of an

aromatic ester, like geraniol, to these molasses baits slightly increased their effectiveness, while the addition of yeast apparently lowered and shortened their period of attractiveness. Another outstanding feature noted in these two years of investigation was the low catches of moths obtained as compared with those secured by investigators in other western states; i.e., Yetter in Colorado (64 to 114 moths per trap) and Spuler in Washington (50 moths per trap in one night).

Owing to the fact that New Mexico differs from Colorado and Washington in daily summer temperatures, rainfall and wind velocity, these factors were studied in connection with the moth catches of 1929. It was found that with the exception of the months of April and May, where occasional temperatures below 60° Fahrenheit occurred, low temperatures could not be considered as reducing the catches of moths. High temperatures in July (i.e., a monthly mean of 78.2° F.) might be in part responsible for the smaller catches of this period although the annual summer rainy period which also occurred at this time (i.e., total precipitation for July, 2.16 inches or .41 inches above normal, and for August, 1.94 inches or .24 inches above normal) was regarded to be the more responsible factor. This assumption was further supported by the fact that the largest catches of the season were obtained between April 12 and May 20, during which period there was no rain. It was also observed that wind, when occurring in amounts exceeding 250 miles per day, apparently decreased bait pan catches during the period when it is blowing most steadily but could not be considered as a retarding factor over any long period of time.

In 1930 all baits were tested in pails somewhat similar to those used by Yetter although certain modifications were introduced (Plate 22). In place of glass containers specially constructed conical galvanized iron pails were used. These were about 18 inches deep, 6 inches in diameter at the top and held two quarts of bait. A six-inch screen sieve was placed immediately beneath the surface of the bait in the top of each pail and served to prevent water-soaked insects from sinking into the narrow end of the cone and also for removing the insects for examination. Each pail was suspended by a continuous rope run through a pulley attached to the crossbeam of the vertical pole erected in the center of the tree. One end of the rope was attached to the handle and the other end to a ring at the bottom of the pail. By this means the pail was prevented from swinging in the wind and could be raised and lowered from the ground. The galvanized iron pails were coated on the inside with paraffin or duco paint to prevent corrosion by the baits. These pails were usually arranged in sets of four to each tree and were used for comparing the various sugar baits and esters included in the experiments.

Since baits consisting of Brer Rabbit cane syrup or Diamalt syrup diluted in water at the rate of one part to ten had proved to be the most effective attrahents during 1928 and 1929, these two materials were again tested and compared. In all of these comparisons Brer Rabbit syrup surpassed Diamalt in its attractiveness and the addition of yeast, either in compressed or dried form, to either of these syrups, lowered their attrahent value. It was again observed that molasses baits which fermented slowly were more attractive than rapidly fermenting ones, and consequently a series of preservative materials was tested in combination with the Brer Rabbit syrup. Of the following, formaldehyde, bichloride of mercury, alcohol, acetic acid, toluene, sodium fluoride and sodium benzoate, the last mentioned material apparently retarded fermentation to the proper degree and materially increased the attractiveness of the bait. Sodium fluoride completely inhibited fermentation and no moths were caught in baits containing this chemical. The results of these comparisons are given in Table No. 1, Series 1.

From the results of these investigations it seemed desirable to obtain further information regarding the chemical nature of the attractiveness of fermenting molasses baits. A series of daily chemical analyses, similar to those made on Oriental Fruit Moth baits by Frost[5], were made of

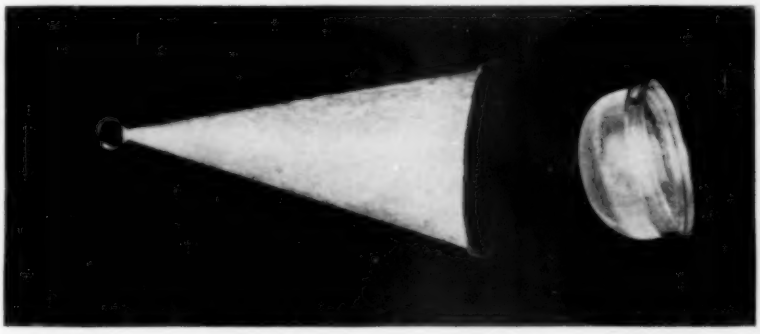
TABLE 1. COMPARISON OF THE ATTRACTIVENESS OF VARIOUS CODLING MOTH BAITS

Series 1, Sweetened Baits + Preservatives

Materials	No. of Days Exposed	Dates of Exposure	Total No. of Moths Caught	Average No. of Moths per Day
Cane Syrup and .2% Sodium Benzoate	26	July 21–Aug. 14	110	4.23
Cane Syrup and .5% Zinc Sulfate	26	July 21–Aug. 14	30	0.11
Cane Syrup and .5% Sodium Benzoate	47	Aug. 19–Oct. 4	133	2.83
Cane Syrup and .2% Formaldehyde	51	Aug. 15–Oct. 4	3	0.05
Cane Syrup and .1% Bichloride of Mercury	51	Aug. 15–Oct. 4	51	1.00
Cane Syrup alone (Check for 51 day series)	51	Aug. 15–Oct. 4	110	2.15
Cane Syrup and 10% Sodium Fluoride	20	July 15–Aug. 3	0	0
Cane Syrup and 8% Toluene*	23	Sept. 12–Oct. 4	0	0
Cane Syrup and 20% Ethyl alcohol	40	April 21–May 30	43	1.07
Cane Syrup and 30% Acetic acid	40	April 21–May 30	3	.07
Cane Syrup alone (check for 40 day series)	40	April 21–May 30	51	1.27

[5]Journal Economic Entomology, 19:3, 1926.

A.—Arrangement of conical iron bait pans in the field.



B.—Details of pan and strainer.

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Series 2, Sweetened Baits + Alcohol or Acetic Acid

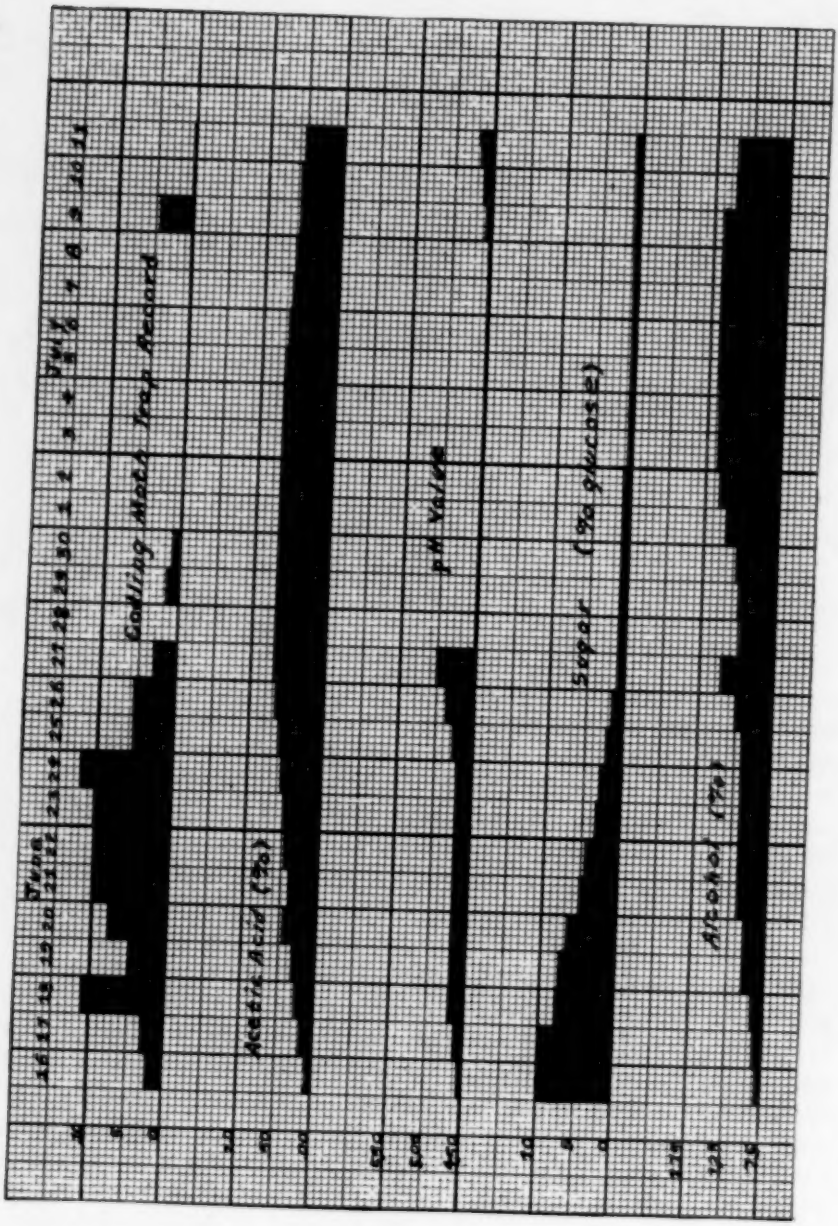
Cane Syrup & Preservative + Acetic Acid .70%	20	July 15–Aug. 3		
Cane Syrup + Acetic Acid 30%	40	April 21–May 30	18	0.90
Cane Syrup & Preservative + Ethyl Alcohol .15%	20	July 15–Aug. 3	3	.08
Cane Syrup + Ethyl Alcohol 20%	40	April 21–May 30	9	0.45
Cane Syrup + Preservative (20 day check)	20	July 15–Aug. 3	43	1.07
Cane Syrup (Alone) 40 Day Check	40	April 21–May 30	0	0
			51	1.28

Series 3, Special Sugar Baits

Dextrose (C. P.) + .5% Sodium Benzoate (10% Solution in Distilled Water)	29	Aug. 15–Sept. 12	3	0.11
Sucrose C. P. + .5% Sodium Benzoate (10% Solution in Distilled Water)	29	Aug. 15–Sept. 12	15	0.52
Dextrose C. P. (= glucose) (10% Solution in Distilled Water)	29	Aug. 15–Sept. 12	14	0.45
Sucrose (C. P.) (10% Solution in Distilled Water	29	Aug. 15–Sept. 12	4	0.13

*Sufficient to form thin film over bait.

samples of molasses baits which were fermenting in the field and the attrahent values of which were ascertained by daily counts of the number of Codling moths captured. These analyses were so conducted as to give an indication of daily changes in percentages of sugar (glucose), alcohol, acetic acid and pH; of fluctuations in yeast populations, as determined by the Breed method; and of the rate of evolution of gas for each twenty-four hour period, as determined by Smith fermentation tubes calibrated against a Frost gasometer. The results of such an analysis of cane syrup bait (Brer Rabbit) are given in Figure No. 48. The curves representing the daily changes in each of the chemical factors are compared with the moth catches of the same period and indicate that the attrahent value of the bait was most closely associated with changes in the decomposition of the sugar, particularly those which precede and accompany the early formation of alcohol. These are first indicated by decreases in the percentage of glucose. Such changes, which are probably also characterized by the formation of esters, the compositions of which are as yet undetermined, are apparently of primary importance in the catching of Codling moths. The growth of yeasts and bacteria and the subsequent conversion of alcohol into acetic acid is of secondary


Average Daily Temperature (°F)
Average Daily Relative Humidity (%)
Average Daily Rainfall (Inches)
Average Daily Wind Velocity (Miles per Hour)
Average Daily Soil Temperature (°F)
Soil pH Value
Sugar (as glucose)
Acetone (%)

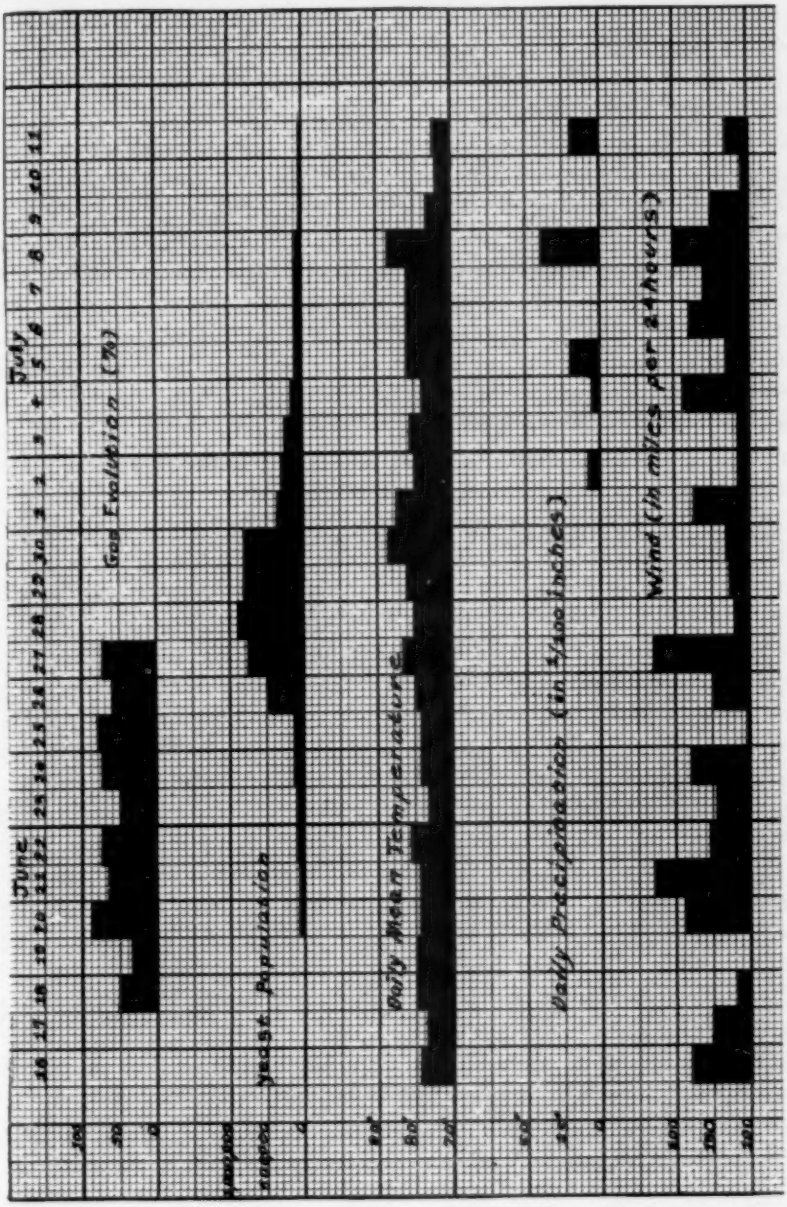


FIG. 48.—Chemical changes in cane syrup bait and weather changes as related to codling moth trap.

importance. The evolution of gas may be important to the extent that it assists in the dispersion of the alcohol and aromatic esters, thereby making their presence more easily detected by the moths.

To further test the influence of these factors, molasses baits were prepared containing 10 per cent sodium fluoride to prevent fermentation and then acetic acid and alcohol were added to certain samples in the amounts of their natural occurrence in fermenting molasses baits and also in sufficiently large amounts to be easily detectable (Table No. 1, Series 2). In this comparison the alcohol baits were decidedly more attractive than the acid baits and only slightly less attractive than cane syrup baits without a preservative. The attractiveness of alcohol was apparently in direct proportion to the amount present (up to 20 per cent) while acetic acid when present in amounts greatly in excess of its normal occurrence in fermenting 10 per cent cane syrup bait (i. e., .7 per cent) was decidedly unattractive or repellent. Other highly acid baits; i. e., ensilage, sourkrout and vinegar, which were tested during the season also showed this same unattractiveness.

In a similar way, ten per cent solutions of the two types of sugar contained in molasses; i. e., dextrose and sucrose, were compared (Table 1, Series 3). It was found that dextrose caught more moths than did sucrose, but when a preservative (sodium benzoate) was added, then the sucrose caught more moths than did dextrose. This indicates that apparently dextrose is normally the more attractive of the two, but sucrose shows a certain amount of attractiveness during its first decomposition through hydrolysis and fermentation, due possibly to the dextrose formed and to the alcohol and gas which may affect the formation and volatility of whatever esters are present. Another characteristic which may account for the difference in attractiveness of the two sugars is that dextrose has a distinctive odor which it retains for a long time after being placed in solution. Sucrose has no odor of its own and apparently does not become attractive until it develops an odor due to decomposition.

The principal weather fluctuations occurring during the time covered by the chemical tests of cane syrup, as shown in Figure 48, are also included in the table. As in 1929, high temperatures and excessively strong prevailing winds seemed to be temporary retarding factors while rainfall, particularly during July, made the daily catches irregular. Owing to the fact that most of the early chemical changes in the bait had taken place before the occurrence of high July temperatures and rainfall, the effect of these weather factors on the rate of chemical change in baits was not obtained.

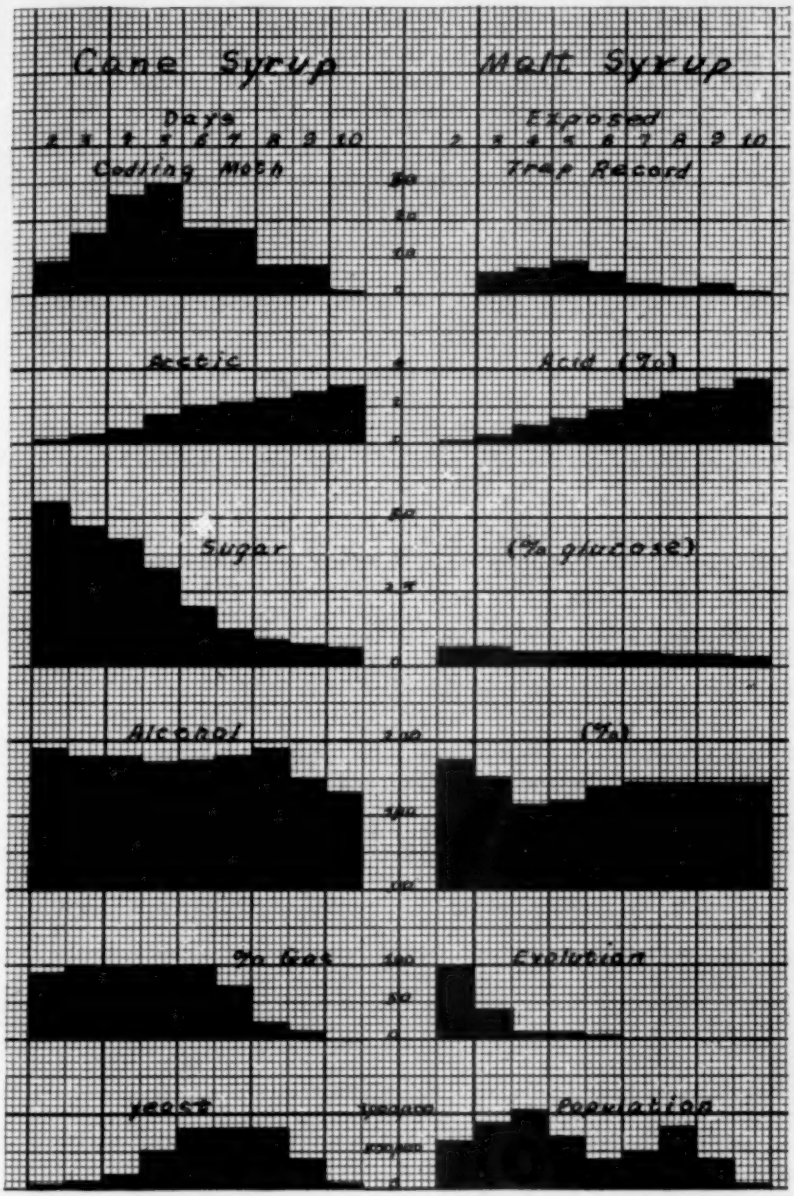


FIG. 49.—Comparison of the chemical changes in cane syrup bait and malt syrup bait as related to their attractiveness to codling moth

Because of the decided difference in the attractiveness of cane syrup and malt syrup baits their chemical properties were studied and are compared in Figure No. 49. It may be seen that during the fermentation process malt syrup produced a lower percentage of glucose, gave off gas over a shorter period and in lower quantity than did cane syrup, produced a slightly smaller amount of alcohol and a larger yeast population. The acetic acid and pH of the two baits were practically identical, and acidity does not seem to be a significant factor.

In addition to these experiments with molasses baits, field comparisons were made of the attractiveness of a number of aromatic chemicals or esters by placing them in "Peterson Evaporation Cups" and floating these on water in the conical bait pails illustrated in Plate 22. These chemicals were not placed in the molasses baits this season because it was desired to avoid interaction between the baits and the esters and thus secure a better idea of their comparative intrinsic values. Of seventeen aromatic chemicals tested, seven were found to be moderately attractive and are listed in Table 2 in the order of their attractiveness. Iso-butyl phenyl acetate, the most attractive of this group, caught a total of 68 moths in 49 days or an average of 1.3 moths per day. Geranyl formate and ethyl oxyhydrate were almost as attractive, catching an average of 1.03 and 1.0 moths per day. Comparing these catches with those of molasses baits, one sample of Brer Rabbit molasses running at practically the same time as the esters but for a longer period; i.e., 51 days, caught 110 moths or an average of 2.1 moths per day, and a second sample of molasses containing .5 per cent of sodium benzoate caught 133 moths or a total of 2.8 moths per day.

TABLE 2. COMPARISON OF THE ATTRACTIVENESS TO CODLING MOTH OF CERTAIN AROMATIC CHEMICALS

Material	Dates Operated	Days Operated	Total Catch	Average Catch per Day per Pan
Iso-butyl phenyl acetate	July 16–Sept 2	49	68	1.38
Ethyl oxyhydrate	Aug. 3–Sept. 2	31	31	1.00
Geranyl formate	Aug. 3–Sept. 2	31	32	1.03
Diphenyl oxide	July 16–Sept. 2	49	42	.85
Citronellal	July 16–Sept. 2	49	29	.59
Bromo styrol	July 16–Sept. 2	49	26	.53
Methyl cinnamate	July 16–Aug. 16	42	13	.30

The reason for the attractiveness of these chemicals is not easily ascertainable because the effect of their chemical properties on insect metabolism is not understood. Some of the various chemical and physical properties of these materials, such as structural formula, molecular weight, density, solubility in water, boiling point, characteristic odor,

and refractive index, were obtained and studied in relation to attractiveness. From this study it appears that chemical structure, molecular weight, and possibly boiling point may be significant factors. All of the seven most attractive materials, except Citronellal, include one or more benzene rings in their structural makeup. All have from eight to twelve atoms of carbon and from one to two of oxygen. Iso-butyl phenyl acetate and methyl cinnamate have slightly similar chemical formulas. On the other hand, the three most attractive materials, iso-butyl phenyl acetate, ethyl oxyhydrate and geranyl formate, possess odors resembling apple blossoms or fruit; so the approach of the odor of the ester to the odor of the natural food of the Codling moth may be of more importance than any other chemical or physical characteristics.

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INJURY TO APPLE TREES FROM THE USE OF A CALCIUM CYANIDE RAW LINSEED OIL MIXTURE IN CONTROLLING THE ROUND-HEADED APPLE-TREE BORER

By A. B. Burrell and G. K. Parris, *Champlain Valley Orchard Laboratory of Cornell University, Peru, N. Y.*

Abstract

In the Champlain Valley fruit section of New York State, a few growers reported very severe injury to apple trees from the use of a calcium cyanide-raw linseed oil mixture for the control of the round-headed apple tree borer, *Saperda candida* Fab. It was found that the injury was most severe when the cambium was exposed by cutting out part of the borers before the material was applied, but that ¼" to ½" of cambium beyond the borer tunnel was killed even when no such cutting was done. Preliminary tests indicate that perhaps the use of some oil other than raw linseed will reduce the danger of injury to the tree.

For the control of the round-headed apple-tree borer, *Saperda candida* Fab., in the province of Quebec, Petch[1] recently recommended applying

[1]Petch, C. E. The round-headed apple-tree borer and its control. Dept. of Agriculture, Canada, Entomological Branch Circular No. 73. 1930.

a mixture of raw linseed oil and calcium cyanide to the parts of the tree where the castings are observed, the treatment being made preferably between May 25 and June 5. The exact composition of the mixture, according to Petch, should be varied according to the temperature, enough calcium cyanide being used to bring the mixture to the consistency of thick paint. While he says that other vegetable oils could be substituted for raw linseed, he considers the latter preferable by reason of its cheapness and availability. He states, "The mixture is not injurious to the trees and is ten times as fast as hand worming." No special precautions are given.

The method was used in 1928 and 1929 by a few fruit growers in the Champlain Valley of New York, who had learned about it from Petch prior to the appearance of his publication. They reported satisfactory results. In 1930, the method was more generally employed, and several cases of severe injury to the trees were noted. This paper reports a study of this injury and the factors connected with its development.

Characteristics of the Injury. It was found that when the treatment is made according to the instructions of Petch, there is ordinarily a killing of the bark and cambium for a distance of ¼" to ½" in all directions from the borer tunnel. Occasionally, a dead strip of bark develops from the crown upward for a distance of a few inches to a foot or more. If the trees are not badly tunneled by borers, they usually make a satisfactory recovery. Hundreds of treated trees in the Champlain Valley of New York, and according to conversation with Petch, thousands in the Province of Quebec, have recovered. If, on the other hand, badly tunneled trees are treated their recovery is doubtful. Many trees severely injured by borers have been completely killed by the treatment. How valuable they would have been if they had lived, is a pertinent question.

The cases of most serious injury were ones in which prior to the application of the cyanide-oil mixture the grower had cut out with his knife such borers as he could readily reach. In these cases, a strip of dead bark originated at the point where the cutting was done and extended vertically for varying distances. Where such cutting was done, but no cyanide mixture applied, no such dead strip developed. In some instances, bark, cambium, and a layer of sapwood were killed for as much as several feet, and of course, branches originating in the dead strip were killed. Frequently, much of the heartwood of trunk and branches was discolored. Ordinarily the killing extended the shortest distance above the point of cutting in the cambium, farther in the bark, and farthest in the sapwood. It very rarely extended more than an inch below (i.e.

toward the roots) from the point of cutting. The dead strip was ordinarily from 1 to 2 inches wide. Callus formation at its margin had commenced before the end of the summer, in most of the trees. Some trees had two or three such strips, their location bearing no consistent relation to points of the compass. (See illustrations.) A species of Cytospora was found commonly growing as a fungous saprophyte in the killed bark.

AMOUNT OF THE INJURY. In the most serious case, somewhat more than 1000 4-year-old McIntosh trees were treated, of which as an estimate, 800 show commercial injury. Probably 300 will be adjudged beyond recovery and replaced next spring. The status of the remaining injured trees is uncertain.

CAUSE OF THE INJURY. Before inquiry had revealed the essential facts of the case, it was assumed that the treatment properly carried out, would be non-injurious. The first hypothesis was that some error had been made in getting the constituents, in mixing them, or in applying them. This hypothesis proved, in the main, untenable for the following reasons. It could not have been due to use of the wrong oil, because identical symptoms developed following the use of oils from widely separated sources. In frequently repeated tests by the authors, characteristic injury resulted even when the mixture was made from a good grade of raw linseed oil obtained at a local pharmacy. It could not have been due to a mistake in obtaining the calcium cyanide because the grade and brand (Cyanogas) were the same as used by Petch. Also, the characteristic injury developed when samples of cyanide purchased in different years and from different sources, were used. Samples of the mixture that caused injury were submitted to Petch, who approved the consistency as being about right. It is possible, however, that the composition of the mixture may have been a factor. In 1928, and 1929 when apparently little injury occurred, most growers used a mixture resembling thin rather than thick paint in consistency. The mixture that caused injury in 1930 contained a larger proportion of calcium cyanide, having the consistency of thick paint. The method of application and the amount of the mixture used, may have been partially responsible for the magnitude of the injury. The extremely serious injury occurred where the mixture was applied as a complete collar for a distance of 12 to 15 inches from the crown of the tree upward; this may be at variance with the somewhat indefinite recommendation of Petch to "apply a liberal coating of the mixture over the areas where the castings are present. . . ." Whatever significance these factors may have had, the striking correlation between severity of injury and exposure of cambium by cutting bark

with a knife prior to applying the mixture, suggested this exposure as the factor chiefly responsible.

To test this, several experiments were made. In the first the bark was removed from a strip ½″ x 5″ on each of 24 branches about one inch in diameter. To the exposed cambium of each, the calcium cyanide-raw linseed oil mixture, made up exactly according to the instructions of Petch, was applied. After a week, 22 branches showed some scorching of foliage, 21 showed a strip of dead bark above (i. e. distal to) the treated area, and all 24 showed browning of the sapwood in a streak distal to the treated area. These symptoms were identical with those described above as occurring as a result of the treatment on 4-year-old McIntosh trees. In two check branches receiving the same treatment except that the bark was left intact, no injury resulted.

The second and third experiments were designed to test whether there is a difference in the toxicity of calcium cyanide mixtures to the tree when made up with different oils. The second experiment included 2 check branches with bark intact, treated with each mixture; none of the mixtures produced any injury when applied to intact bark. The results are summarized in Tables 1 and 2.

The mixture made with castor oil appears to be the least toxic, while that made with neatsfoot is apparently the most toxic. Even with the castor oil mixture, there was some injury after 5 weeks in the case of the extreme exposure of tissues here employed.

In a fourth experiment, calcium cyanide (Cyanogas) powder was applied to an area of exposed cambium ½ x 5″ for each of 4 branches. After 4 days, 3 branches showed scorching of leaves, and each of the 4 showed a streak of discolored sapwood. The length of this streak beyond the treated area was 2″, 4″, 4″, and 6″ respectively in the individual branches. There was no apparent injury to the bark.

A consideration of these results and those shown in Tables 1 and 2 shows that the oil influences the amount of injury. However, none of the 5 oils previously mentioned, had any injurious effect when applied alone either to freshly exposed cambium or to sound bark. Probably the oil influences the amount of injury by influencing the penetration of the calcium cyanide.

Discussion. The foregoing observations and experiments were spread over the period from mid-June to late September. In several instances, a treatment was repeated after a few weeks, but without any definite correlation between date of treatment and results obtained. However, as all of the experiments and most of the observations are based on treatments later than the dates recommended by Petch, the work should

TABLE 1. EXP. II. INJURY TO APPLE BRANCHES ABOUT ONE INCH IN DIAMETER, TREATED WITH MIXTURES OF CALCIUM CYANIDE AND DIFFERENT OILS; BARK REMOVED FROM AN AREA ½ x 5″ PRIOR TO EACH TREATMENT

Oil Used in Making the Mixture	No. of Branches Treated	No. of Branches Showing Scorching of Leaves After 4 days	No. of Branches Showing Discolored Strip of Bark		Length of Discolored Streak of Sapwood in Individual Branches Above Place of Treatment	
			After 4 days	After 5 weeks	After 4 days	After 5 weeks
Raw Linseed	5	5	3	5	½″, 6″, 1″, 2″, ½″	17″, 15″, 7″, 22″, 5″
Cottonseed	5	5	4	*	¼″, 2″, ¼″, 3″, 4′	7″, 5″, 11″ (2 cut off for photographs)
Olive	5	5	1	*	¼″, ½″, 8″, ½″, 1″	9″, 10″, 11″ (2 cut off for photographs)
Castor	6	0	0	*	0	2″, 5″, 5″, 10″, 5″, 7″
Neatsfoot	5	5	5	*	7″, 4″, 16″, ½″, 1″	40″, 28″, 36″ (2 branches dead)

*No observation.

TABLE 2. EXP. 3. INJURY TO APPLE BRANCHES ABOUT ONE INCH IN DIAMETER, TREATED WITH MIXTURES OF CALCIUM CYANIDE AND DIFFERENT OILS; BARK REMOVED FROM AN AREA ½ x 5″ PRIOR TO EACH TREATMENT; OBSERVATION 4 DAYS AFTER TREATMENT

*Oil Used in Making the Paste	No. of Branches Treated	No. of Branches Showing Scorching of Leaves	No. of Branches Showing Discolored Strip of Bark	Length of Discolored Streak of Sapwood in Individual Branches Above Place of Treatment
Raw Linseed	5	5	2	6″, 1″, 2″, 4″, 5″
Cottonseed	5	5	5	13″, 9″, 12″, 9″, 6″
Olive	5	5	2	2″, 6″, 4″, 7″, 5″
Castor	5	0	0	¼″, ¼″, ¼″, 0, 0
Neatsfoot	4	4	4	6″, 12″, 9″, 17″

*Mixture = 30 cc oil plus 40 grams Calcium cyanide (Cyanogas) except in the case of Castor oil, which, because of its high viscosity, required 40 cc of oil to bring the mixture to the same consistency as the others.

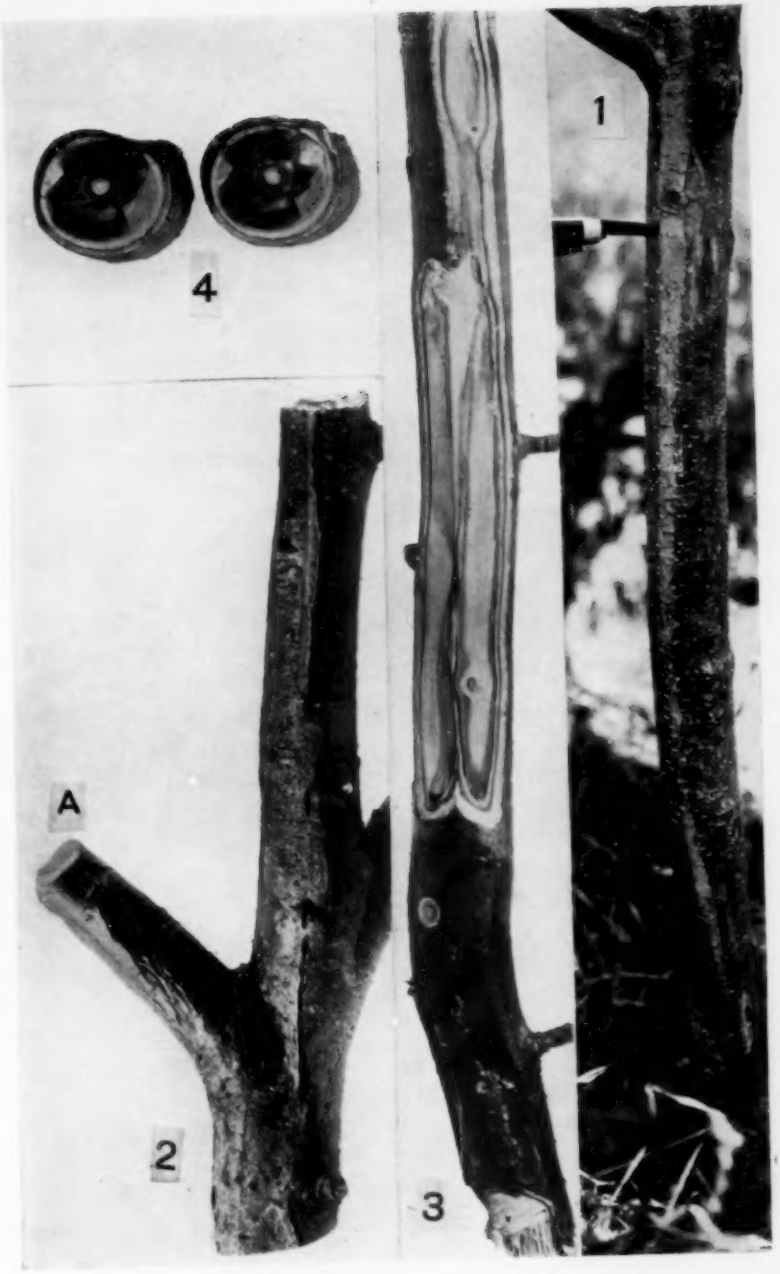
be repeated around the first of June. Possibly the injury would be less if the treatments were made during a cooler part of the year. This is suggested by the fact that June 1930 had an average temperature 4.6°F. above normal for the region, there being 22 days when a maximum of 75°F. or above was attained, and 9 days when the thermometer registered 85°F. or above. Conceivably, a chemical treatment might be fairly safe in the province of Quebec, but less so in warmer regions. Temperature may possibly help explain the relative freedom from injury from the treatment in 1928 and 1929, in commercial practice in Champlain Valley orchards. The relation of temperature should be tested experimentally.

Since the least injury resulted from the castor oil mixture, further tests of the efficiency and safety of this mixture in borer control are desirable. There was no obvious correlation between vigor of tree, or variety, and amount of injury. Whether the killing of ¼″ to ½″ of tissue beyond the borer tunnel, which apparently occurred even when the recommendations of Petch were strictly followed, is so serious as to totally disqualify the method, is problematical.

Conclusion. Recommendations of this method of borer control should carry with them explicit precautions against cutting bark prior to treatment. Further tests to help define the safety margin are imperative.

Explanation of Plate 23

1. McIntosh tree 4 years old, from which some borers were cut out, then a calcium cyanide-raw linseed oil mixture applied. The dark-colored bark is dead, the light-colored alive. Most of the bark is alive on the side of tree not shown.
2. Segment of McIntosh branch taken 3 feet above point of applying calcium cyanide-raw linseed oil mixture to crown of tree from which borers were previously removed by cutting.
3. Longitudinal section of branch injured by application of calcium cyanide-cottonseed oil mixture to exposed cambium near basal end of branch segment here shown. A few inches above area of application, note live outer bark, dead inner bark, live cambial region, discolored layer of sapwood, and normal heartwood.
4. Cross-sections of a ¾″ branch cut off at "A" in Fig. 2. Such discoloration of heartwood is common in cases of very severe injury.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REARING HOUSEFLIES FOR TESTING CONTACT INSECTICIDES

By GEORGE L. HOCKENYOS, *Urbana, Illinois*

ABSTRACT

A technique is described for rearing houseflies for testing purposes. It differs from that usually employed only in the media and apparatus used. Improved testing cages which make possible more rapid tests are also described and some representative results given. A method for making tests on individual houseflies is described and it is shown that certain contact poisons are absorbed directly through the body wall and do not need to enter the trachea.

The desirability of having houseflies available for testing insecticides throughout the winter months has led to the practice of rearing successive generations through the winter months. Grady,[1] in August 1928, described a satisfactory method of accomplishing this and credits Glaser[2], 1927, with being the first to use yeast in suspension as a supplementary winter food for the larvae. The method described by Grady was followed with certain modifications in the work here described and since his paper is readily available, only the modifications will be discussed.

REARING. The flies were grown in an ordinary room, at an average temperature of 85°F. The humidity was not controlled and it is believed now that it would have been better to have done so. The two types of jars used to hold the breeding media are shown in Figure 50. The smaller is the standard battery jar recommended by Grady. This was found to give satisfactory results but required more attention than the larger jar which was of 3 gallon capacity. The increased bulk of breeding media was apparently conducive to more even conditions of moisture and temperature than the smaller jars afforded. It was observed that at times the maggots fed near the surface, and at other times deeper in the mass.

At first, fresh horse manure free of straw was used with yeast suspension as a supplementary food. It had been noticed during the summer however, that maggots were even more abundant in heaps of hog manure than in piles of horse manure and an attempt was made to adapt this material to laboratory use during the winter months. Hog manure alone tended to pack, to the exclusion of the necessary air, and it was found that a mixture of one part fresh-straw-free hog manure with three or four parts of fresh straw-free horse manure gave the best results. This combination provides sufficient aeration and at the same time gives more

[1]Grady, Jour. Econ. Ent., Vol. 21, pages 598–604.
[2]Glaser, Journ. Econ. Ent., Vol. 20, pages 432–433.

uniform moisture conditions. Less supplementary feeding is required as this material seems to provide more nutrient per unit of space than horse manure alone. It was noticed that the larvae usually fed on the hog manure by preference.

The type of cage shown in Figure 50 was used entirely in this work. It is easily constructed of copper fly screen and one end is closed by a cloth extension with a draw string to provide a means of closing it. The diameter is such that it just fits over the jars and when the cloth extension is opened and slipped over the jar, it provides, with the jar, a completely closed cage.

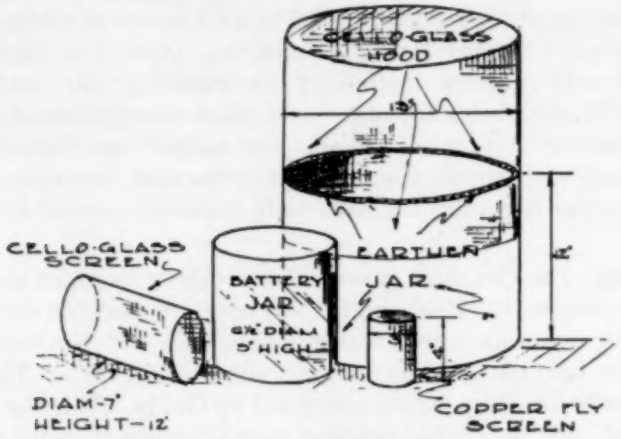

FIG. 50.—Jars for breeding media.

In operation the jar is filled about two-thirds full with the mixture mentioned, and a few flies of both sexes placed in the cage, which is then slipped over the jar. Bread moistened with milk and sugar is used for food and is placed in the jar from time to time. If the lower part of the cage be covered with a piece of black sateen or other dark cloth, the flies will go to the top and the cage may be removed and the cloth extension closed at will for transferring specimens. In two or three days the maggots will be in evidence and the adult flies may be removed. As the maggots reach their maximum growth, they pupate in such part of the jar as suits their needs. If the media be wet they will pupate at the surface and a layer of pupae one-half inch deep is not uncommon in the larger jars. If the media be allowed to become rather dry on the surface, they will pupate below the surface. If active fermentation tends to produce considerable heat in the mass, this alone tends to send them to the surface. In a series of experiments the full grown maggots were.

given their choice, sand or soil, wet, moist or dry, and shade or dark. Their preferences in these respects were not very marked, but moist, dark soil seemed to be the favorite. Conditions of aeration and temperature were alike in these experiments.

The pupae may be left in the jar until they emerge or may be removed by emptying the media out and spreading it to partially dry when the pupae may be removed by sifting. In any case, once emerged the newly issued adults are kept in the cage until four or five days old before being used for test purposes. During this maturing stage the flies may be kept in a cage open end down on a table with a dish of food under the cage. If it becomes necessary to transfer the flies from one cage to another, the little cylinder of celloglass shown in Figure 50 is placed between the open ends of the two cages, the draw strings drawn and when the cage containing the flies is darkened, they will go into the new cage.

The jars and cages should be scalded with steam occasionally as a species of parasitic mite is very troublesome. When present, this mite is found on the under side of the thorax between the segments of the thorax and also between the coxae of each segment. Once established, the mites swarm through the breeding media and infestation of the flies will be nearly 100%. Few larvae are produced under such conditions but this is apparently due to the devitalizing of the adult as eggs placed in a small glass dish with a large number of mites hatched well and the young maggots were not parasitized.

STORING. Late in the summer it is possible to produce flies in great numbers out-of-doors. The method used was to stretch a coarse screen over a pan three feet by three feet by three inches deep. Fresh hog manure placed on the screen was soon swarming with maggots and as they matured they crawled to the edge and dropped into the pan in which was a half inch of sand or sifted soil, where pupation takes place. In this manner it is possible to get literally gallons of pupae with little effort.

The desirability of carrying such material over into the winter by means of cold storage suggested itself at once and since Graham-Smith[3], 1914, observe that pupae may take 28 days or more to emerge, it seemed that there was some assurance of success. Accordingly, quantities of pupae, larvae and adults were placed in separate screen containers and stored in four different rooms at temperatures of approximately 10°, 32°, 37° and 47° respectively. The air is quite humid in all these rooms. Pupal storage at the three lower temperatures was unsuccessful, but at 47° showed some promise.

[3]Graham Smith, 1914, "Flies and Disease," page 46.

This suggested that still higher temperatures might be desirable and accordingly pupae separated into groups 1–2 days old and 4–5 days old were stored in cases at 45°–55° and 60° respectively. It was found that the 4–5 day old pupae soon either emerged at this temperature or else died in the pupal cases. None of the 1–2 day old pupae emerged while held in any of the above temperatures. Pupae stored at 55° gave best results and an emergence of 75% may be expected at the end of two weeks.

Storage of larvae was not satisfactory. At 10° and 32° they immediately died and at 37° they lived only a week or so. At 47° they lived two or three weeks and part of them pupated at this temperature, but many of the pupae were deformed and the flies produced were of low vitality.

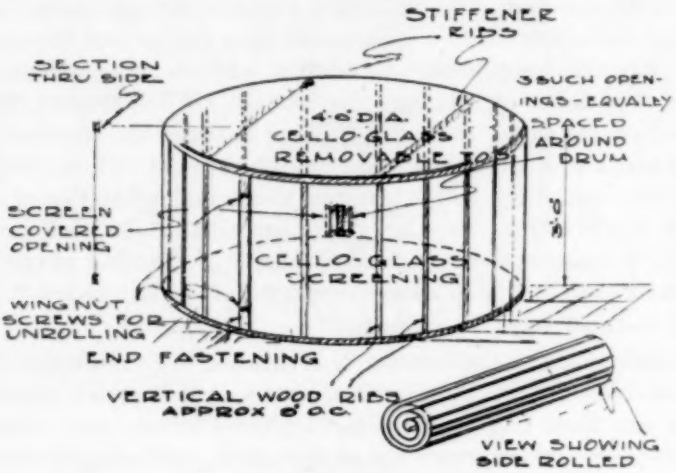

FIG. 51.—Celloglass cage.

Storage of adults was unsuccessful due to the attacks of fungi.

Storage of eggs showed no promise but the eggs hatched in some instances at surprizingly low temperatures. Hatching occurred in one day's time at 50° and some few hatched at 37°.

TESTING. The most common method of testing household sprays on flies is to free them in a tight box of considerable size, say six feet by six feet by six feet, and apply the spray through little doors. A modification of this idea is shown in Figure 51. This cage is made of celloglass, which is tight, semi-transparent and perfectly flexible. The cage is three feet high and four feet in diameter. The wooden strips may be of any small stuff and serve merely to give strength and rigidity to the cage when set up. The two ends are fastened to strips of wood through which are

passed two bolts and winged nuts are used for convenient fastening. The top is celloglass stretched on a circular frame. The whole thing can be set up in a few minutes and can be taken down and washed after each test. Three windows large enough to admit flies and the spray nozzle are provided and closed with a fastening that can be understood from the drawing.

In practice, this cage is set up on a large sheet of paper, the flies admitted through a window by the method previously mentioned and the spray applied in equal quantities from each window. If a light be placed inside the cage the flies may be observed as shadows from the outside or

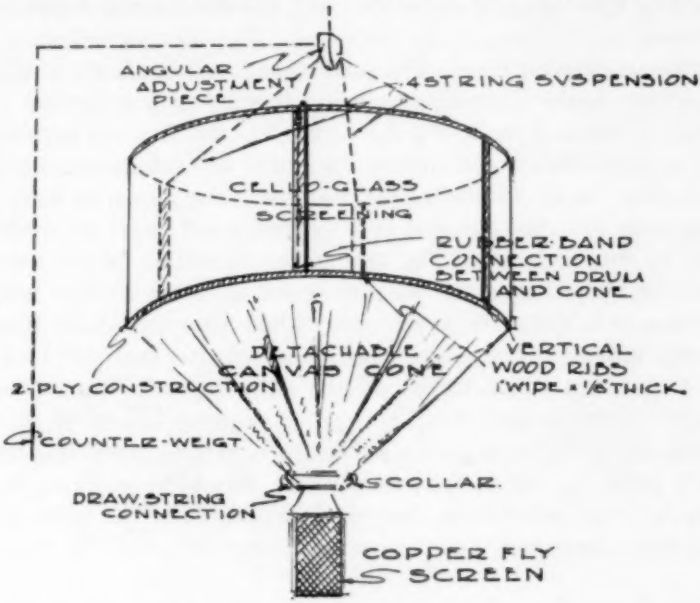

FIG. 52.—Modified celloglass cage.

they can be observed without a light by the operator covering his head with a dark cloth, after the manner of a photographer. If desired, the windows can also be opened for observation. After observation is completed the cage is taken down, the dead flies on the paper removed for observation as to recovery and the cage reassembled after cleaning. Using a typical commercial pyrethrum household spray, applied with a small household sprayer, 2 cc. gave 75% down, 2½cc.—97% and 3cc —98% down in five minutes time. Since the cage is of 37+ cubic feet capacity, this means that approximately 2 ounces per 1000 cubic feet is required to give a good kill with this type of cage.

A second type of cage of the same dimension but of open fly screen was constructed as shown in Figure 52. The same celloglass top was used and the bottom was a conical piece of cloth, which being fastened to its separate hoop, could be readily fastened and detached from the cage proper by means of four pairs of hooks held by rubber bands. The cage was suspended from the ceiling by means of a pulley and counterweight and since it was suspended by one cord could be readily turned on its axis. The cloth bottom is lined with paper fastened to the bottom with pins and occasionally replaced. The apex of the cloth cone terminates in a small collar of three inch diameter. In operation, a small cage containing flies is placed under the cone, the draw string drawn around the collar and the small cage darkened. The flies immediately go up into the large testing cage. The small cage is left in place and the large testing cage slowly rotated, spray being directed against the flies from a distance of two and one-half feet. As the flies fall they roll back into the small cage and this is removed at the end of five minutes and a second put in place for an additional ten minutes. The flies remaining in the testing cage are then counted and the two small cages set aside for a period to note recovery. The sum of the flies down in the two small cages, plus those left in the big cage, gives the total number admitted, and it is easy to calculate percentages without counting all the flies while alive and moving. The testing cage is cleaned after each test by a forceful jet of steam which cleans off the adhering spray and dries very quickly. Using a small hand sprayer, it requires 7½ to 10 cc. of pyrethrum spray to give as good a kill as 2½cc. in the tight, celloglass cage. This is probably due to the openness of this type of cage, and also to the fact that whereas in the closed cage most of the spray hits the insect from above, in the open cage most direct hits come on the underside.

It was found that when a large hand sprayer of twice the delivery per stroke of the small household type was used a larger kill per cc. of spray was obtained with the open cage. A comparison then was made of the delivery of the two sizes of sprayers by using a spray chute as shown in Figure 53. This is a box eight feet long, 12 inches high and six inches wide, open at both ends save for a cross brace. The top is detachable. In operation, a strip of white glazed paper is laid down on the floor of the box, with a narrow strip of wood laid down the center of the paper, partly to hold it in place and also to accent the pattern produced by the spray droplets. A small amount of Sudan III is added to the oil spray and one stroke of the pump sent down through the chute holding the end of the sprayer against the cross brace at the end of the chute. A pattern of red

droplets is produced on the white glazed paper and this is accented when the wooden strip is removed from the middle of the floor and the white paper exposed to view. A few tests showed that the larger sprayer was capable of sending droplets from seven to eight feet through the chute, while the small household sprayer did not reach more than four to five feet in noticeable quantity. The individual droplets also averaged larger in the large sprayer. A few very large drops were delivered within a few inches of the mouth of the sprayer. This presumably at the end of the stroke. Apparently then, one reason the larger sprayer was more effective when used with the open type of cage is that it is capable of hitting flies

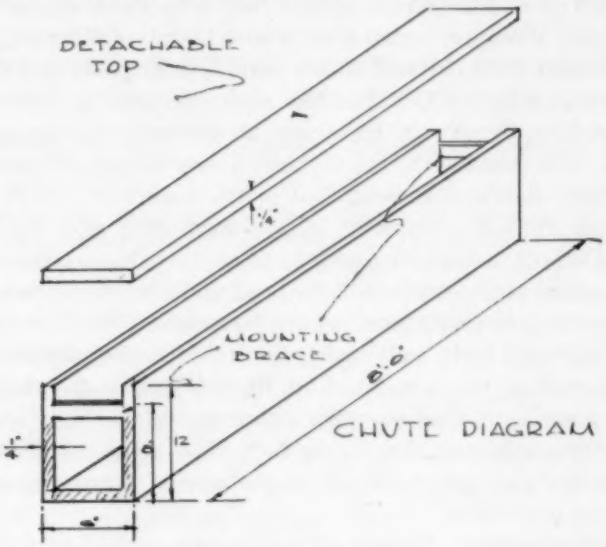

FIG. 53.—Spray chute.

not only on the near but the far side of the cage as well. It seemed also possible that the difference might be due to the larger droplets being more effective than the smaller. Then, too, a spray reaching only the near side of the screen hits only the underside of the flies, whereas one reaching to the far side hits them on the back as well.

These last two possibilities were further studied by means of tests on individual flies. It was found to be entirely possible to etherize flies, treat them with a single droplet of contact spray and get the effectiveness in this way. Etherization has the disadvantage that it is easy to overdose and thus get poor recovery in the controls. It was found more practical to place a number of flies in a Mason fruit jar and seal it with a lid on the underside of which is fastened a bag of anhydrous calcium

chloride to prevent moisture condensing on the flies. This jar is then immersed in a freezing mixture of water, ice and salt. As soon as about one-half of the flies are down with cold numbness, the jar is lifted out and in a few minutes all are quiet. They are removed to a small tin plate which is floated on a freezing mixture to keep them numb. They will remain quiet for an indefinite time in this way, and will recover completely if not left on the ice bath more than 30 minutes.

The droplets of spray were applied by dipping a wire of known gauge to a measured depth in the spray fluid and then touching the end of the wire to the insect at various points of the body. The tip of the wire was rounded off and the size of droplet delivered was fairly constant for any one liquid, though it varied greatly with liquids of different viscosity. The results were later checked with a Leur syringe graduated to 1/100″ and delivering droplets 1/250″. The materials used in the tests were refined kerosene, pyrethrum spray and an aromatic halogen compound under test. The tests with cold numbed flies were more consistent than with etherized flies and showed that of the numerous places that the droplets were applied, pyrethrum sprays were most effective when applied to the side of the abdomen and the aromatic halogen compound most effective applied at the juncture of the head and thorax. Since there are no body openings in this region, it must be assumed that the spray is absorbed through the body wall itself. Shafer[4] in 1919 concluded that certain solids, such as borax and sodium fluoride can be absorbed through the body integument after partially dissolving in the body exudations. Wardle[5], 1928, calls attention to the fact that arsenical dusts are absorbed directly through the chitin in the case of grasshoppers, so this phenomenon is not new.

In a similar manner, droplets of spray were applied to the anterior, posterior and middle portions of housefly pupae and it was shown that while the anterior end was the most susceptible, and the middle portion the least, the difference was not very great, being roughly, in the ratio of 5–7–9, as regards numbers of flies emerging after treatment. The relative effectiveness of the three regions was approximately the same for the refined kerosene, the pyrethrum spray and the aromatic halogen compound.

Summary

1. It has been found that a mixture of one part hog manure with ¾ parts horse manure is a more satisfactory media for breeding house flies than horse manure alone.

[4]Shafer, 1915, Michigan Technical Bull. No. 15, Part III.
[5]Wardle, 1928, The Problems of Applied Entomology.

2. Some convenient types of breeding and testing cages have been designed and shown to be practical.

3. Storage of housefly adults, larvae and eggs is probably not practical but pupal storage shows signs of being a useful means of carrying houseflies for a limited time.

4. A convenient means of getting the distribution patterns of spray pumps has been described.

5. A simple means of applying constant spray tests has been described and it has been found that some contact sprays can be effective by direct penetration of the body wall.

THE RELATIVE TOXICITY OF ROTENONE AND NICOTINE TO *APHIS RUMICIS* L. AND MOSQUITO LARVAE

By H. H. SHEPARD, *U. S. Bureau of Entomology, Washington, D. C.*

ABSTRACT

Rotenone has been shown to be more toxic than nicotine when applied as a contact insecticide to *Aphis rumicis* and mosquito larvae. Deterioration in either acetone or alcohol stock solutions was not detected in these tests of toxicity. The effect of acid or alkali added to rotenone suspensions has been investigated and discussed in connection with the spreaders, sodium fish-oil soap and saponin.

RELATIVE TOXICITY OF ROTENONE AND NICOTINE AS CONTACT INSECTICIDES. In 1923 Fryer et al (*1*)[1] reported that they found extracts from derris roots "to be slightly but definitely more toxic than nicotine." In their experiments silkworms were dipped in suspensions of derris root and its constituents. One per cent saponin was used as a wetting agent and to render the suspensions permanent.

The same authors in a like manner compared the toxicity of "tubatoxin," a white crystalline product of the roots, with that of nicotine. This tubatoxin (m.p. 163°) is now known to have been rotenone, although it may have been somewhat mixed with other constituents of the roots. From their Table 4 the following figures have been selected:

Tubatoxin		Nicotine	
Per Cent	Marks	Per Cent	Marks
0.05	100	0.092	100
.025	85	.046	80
.0125	37.5	.023	37.5
.0025	30	.0023	0
.00125	10		

The marks awarded to each percentage were derived by allowing 10 for a dead silkworm, 5 for one in a moribund condition, and 2.5 for one

[1]Reference is made by number to "Literature Cited."

affected but not moribund. Apparently the results were recorded at the end of two or three days. These figures show that rotenone is definitely more toxic than nicotine when used as a contact insecticide.

Tattersfield, Gimingham and Morris (*2*) showed in comparative toxicity curves for "tubatoxin" and nicotine that the toxicity of the former is "of a distinctly higher order than that of nicotine."

In the present investigations spray tests have been conducted with a sample of rotenone of high purity, kindly furnished by Dr. R. C. Roark of the Bureau of Chemistry and Soils. In these experiments the rotenone was first dissolved in 95 per cent alcohol. This alcoholic stock solution was made at a strength of 0.25 gm. in 100 cc. It was found necessary to warm the mixture somewhat in a water-bath in order to dissolve the rotenone entirely. On dilution with distilled water a stable milky suspension results. Colonies of aphids (*Aphis rumicis* L.) on nasturtium plants were sprayed with the various dilutions according to the method the details of which have been described elsewhere (*3*).

Both rotenone and nicotine were tested in duplicate at the same concentration on the same day. All the tests were made within as few days as possible. The spray mixtures were made freshly each day. Saponin at 1 per cent concentration was used as spreader, the required amount of a stock solution of 5 or 10 per cent saponin being added after the rotenone suspension was diluted somewhat with water. The results of these tests are given in Table 1.

TABLE 1. COMPARISON OF ROTENONE AND NICOTINE AS CONTACT INSECTICIDES AGAINST *Aphis rumicis* L. ON NASTURTIUM PLANTS. SPREADER, 1 PER CENT SAPONIN. EACH MORTALITY FIGURE IS THE AVERAGE OF TWO SIMULTANEOUS TESTS

Concentration (Grams per 100 cc.)	Rotenone		Nicotine	
	Number of Aphids	Per Cent Kill	Number of Aphids	Per Cent Kill
0.02	431	95.4	496	70.4
.01	1012	81.2	851	36.2
	721	63.4	725	39.0
	711	91.0	344	65.7
.001	753	39.8	780	27.4

These results are very similar to those presented in comparisons of rotenone and nicotine in the papers previously mentioned (*1*, *2*). Wide variation in the results at 0.01 per cent concentration is probably due to their location toward the middle part of the toxicity curve. The toxicity of rotenone as a contact insecticide is seen to be definitely higher than that of nicotine.

Davidson (*4*) has recently published the results of some tests of rotenone suspensions against *Aphis rumicis* on nasturtium plants. He found

that a concentration of 1:200,000 (=0.0005 per cent) without spreader killed 100 per cent of the aphids. However, these results were obtained by counting the mortality each day until no further kill was observed, the period of observation thus covering several days in the case of a slowly acting poison such as rotenone. Davidson, in a private communication to the writer, reports that individual tests on aphids such as *Brevicoryne brassicae* L. (cabbage aphid) and *Myzus persicae* Sulz. (green peach aphid), with rotenone suspensions at 1:100,000, but treated in different ways, resulted in 89.0, 48.4, 64.0, 22.4, and 46.5 per cent mortality at the end of one day, but at the end of four days the same experiments respectively gave 95.6, 88.1, 95.5, 70.0, and 90.7 per cent mortality. These figures show the desirability of following the course of poisoning until the action is complete.

Another comparison of rotenone and nicotine has been made by immersing mosquito larvae (*Culex pipiens* L.) for a given time in suspensions or solutions of those compounds and then removing the larvae to distilled water to observe the extent of recovery after twenty-four hours. The results are given in Table 2. The figures indicate the combined percentages of killed and paralyzed larvae. No mortality has been observed in distilled-water controls.

TABLE 2. COMPARISON OF ROTENONE AND NICOTINE AS LARVICIDES AGAINST MOSQUITO LARVAE (*Culex pipiens*). NO SPREADER. IN EACH EXPERIMENT TEN GROUPS OF TEN LARVAE WERE USED

	0.01 Per Cent Nicotine Per Cent Kill	*0.01 Per Cent Rotenone* Per Cent Kill
30-minute exposure	8	41
	13	28
Mean	10.5	34.5
2-hour exposure	17	79
	14	73
Mean	15.5	76.0

ROTENONE IN VARIOUS SOLVENTS. Jones and Smith (5) have recently published data on the solubility of rotenone in various organic solvents. It is of interest here that they found that at a temperature of 20°C. saturated solutions of rotenone in acetone contained 6.6 grams per 100cc. and in absolute ethyl alcohol contained 0.2 grams per 100 cc. For purposes of comparison there may be mentioned the solubility figures of these authors for rotenone in benzene (8.0 grams per 100 cc.) and in chloroform (47.2 grams per 100 cc.). "The alcohols and ether, contrary to statements found in the literature, are rather poor solvents for rotenone."

It seemed desirable to test stock solutions of rotenone in which different solvents had been used. In this way it would be possible to eliminate errors in the determination of toxicity that might be due to the influence of the solvent. A 1 per cent acetone solution was easily prepared in the cold. As mentioned previously, ethyl alcohol (95 per cent) was found to take up only enough rotenone to make a 0.25 per cent solution if it was warmed slightly in a water-bath. No crystals of rotenone were observed in it upon cooling or after nearly a year of standing. These stock solutions were kept in subdued light in stoppered flasks.

Without doubt there is considerable variation in the results obtained from spray tests of the type utilized in this investigation, especially owing to variations in the susceptibility of *Aphis rumicis* under greenhouse conditions at different seasons. No systematic study of such a variation has been attempted yet. To this source of error is probably due an apparent increase in the toxicity of stock solutions of rotenone which was observed in the case of both acetone and alcohol solutions when they were allowed to stand over a period of several months. A dilution of 1 part in 200,000 (equal to 0.0005 per cent) once was found to kill 77.9 per cent of a population of *Aphis rumicis*. At another time 1 part in 100,000 (equal 0.001 per cent) killed only 39.8 per cent, the figure given in Table 1. These results from dilutions in the ratio of 1:2 are quoted to show that they are too close for comparisons to be made unless the experiments have been conducted with the same materials at the same time.

In general it was found that sprays made from acetone and alcohol stock solutions were of the same toxicity. For instance the aphid mortality from the application of 0.1 per cent rotenone (acetone stock) was 95.4 per cent and 83.7 per cent from 0.01 per cent rotenone; and the kill in tests with suspensions made from an alcoholic stock solution was 99.0 per cent for a 0.1 per cent suspension and 86.6 per cent for a 0.01 per cent suspension.

Tattersfield, Gimingham and Morris (*2*), in discussing the physical nature of suspensions derived from derris extracts, say that "spray fluids prepared direct from alcoholic extracts of the leaf were colloidal in type. Further work of a quantitative nature is needed to make clear the significance of particle size in this connection." Most of the dilutions of stock solutions of rotenone in either alcohol or acetone with water had the appearance of weak milk, even after standing for a day or two. Supposedly the rotenone was present in the form of extremely finely divided solid particles, the size depending probably on the physical conditions of the dilution.

REDUCTION IN EFFICIENCY OF ROTENONE SUSPENSIONS AFTER STANDING. Previous to this study apparently no investigation had been made of the effect of ordinary spreading agents upon the efficency of rotenone suspensions allowed to stand for a considerable time before use. In their tests with *Aphis rumicis* L. Tattersfield, Gimingham and Morris (*6*) demonstrated the compatibility of 0.5 per cent "soft soap" with similar suspensions from aqueous extracts of a species of *Tephrosia* for immediate use. "The soft soap used was itself toxic to these insects, but it was desirable to put through a few tests as it seemed possible that the poisons might be affected in an adverse way by this material. This was found not to be the case and soft soap may safely be used with aqueous extracts. In these experiments, controls showed that probably about 50 per cent of the deaths might be accounted for by the soap alone."

TABLE 3. RESULTS OBTAINED FROM SPRAYING *Aphis rumicis* ON NASTURTIUM PLANTS AT VARIOUS DATES OVER A PERIOD OF ABOUT SIX WEEKS WITH A SERIES OF SPRAYS THAT HAD BEEN ALLOWED TO STAND THAT LENGTH OF TIME

SERIES I

Date of Application 1930	0.01 Per Cent Rotenone and 0.3 Per Cent Soap Per Cent Kill	0.01 Per Cent Rotenone and 1 Per Cent Saponin Per Cent Kill	0.01 Per Cent Rotenone (no Spreader) Per Cent Kill
Feb. 12 (fresh)	100.0	78.7	96.4
Feb. 17	84.1	48.4	85.4
Feb. 20	85.3	82.4	76.6
Feb. 24	80.0	67.5	67.9
Feb. 28	59.5	58.3	63.7
Mar. 7	68.1	62.7	87.1
Mar 27	—	—	58.4
Date of Application 1930	0.3 Per Cent Sodium Fish-Oil Soap Per Cent Kill	1 Per Cent Saponin Per Cent Kill	Distilled Water Per Cent Kill
Feb. 12 (fresh)	59.6	27.5	15.0
Feb. 17	36.9	21.6	17.2
Feb. 20	30.6	29.9	16.2
Feb. 24	36.5	30.0	21.8
Feb. 28	18.3	16.9	11.3
Mar. 7	22.7	19.0	17.0
Mar. 27	—	—	—

Experiments have been made to determine the efficiency of rotenone suspensions during a period of several weeks after their preparation. Suspensions without spreader were compared with those containing either 0.3 per cent sodium fish-oil soap or 1 per cent saponin. Tests of efficiency were made upon colonies of *Aphis rumicis* on nasturtium plants. The aphid population for each test ranged from 102 to 552 with an average of 288.

TABLE 4. RESULTS OBTAINED FROM SPRAYING *Aphis rumicis* ON NASTURTIUM PLANTS AT VARIOUS DATES OVER A PERIOD OF ABOUT FOUR WEEKS WITH A SERIES OF SPRAYS THAT HAD BEEN ALLOWED TO STAND THAT LENGTH OF TIME. SAME AS PRECEDING TABLE, EXCEPT THAT NICOTINE HAS BEEN USED IN THE COMPARISONS.

	Series 2.				
Date of Application	0.01 per cent Rotenone and 0.3 per cent soap	0.01 per cent Rotenone and 1 per cent Saponin	0.01 per cent Rotenone (no spreader)	0.01 per cent Nicotine and 0.3 per cent soap	0.3 per cent Sodium Fish-oil soap
1930	Per cent Kill	Per cent Kill	Per cent Kill	Per cent Kill	Per cent Kill
Mar. 6 (fresh).	98.7	78.6	98.0	96.0	28.1
Mar. 13.....	83.0	77.6	88.2	89.1	23.6
Mar. 20.....	78.6	80.9	92.1	77.9	28.6
Mar. 27.....	78.5	79.2	80.6	81.6	40.9
Apr. 3.....	67.8	70.0	75.8	95.2	32.1

The hydrolysis of soap in water produces free alkali. On the other hand saponin has an acid reaction (about pH 4.8 in 1 per cent concentration). Hence, in view of the rather indecisive results from tests in which the spreaders soap and saponin were used, it was thought of interest to conduct similar tests to determine the effect of either acidity or alkalinity on the toxicity of rotenone. Nasturtium plants colonized with aphids were sprayed as in the previous experiments, using rotenone alone and in combination with 0.01 N sodium hydroxide and with 0.01 N sulphuric acid but without any spreader. The results of these tests are given in Table 5. Check experiments with sodium hydroxide or sulphuric acid alone killed only from 12.1 to 16.4 per cent of the aphid population, results much like those obtained from distilled water checks (16.0 per cent kill).

TABLE 5. EFFECT OF ALKALI AND ACID ON DETERIORATION OF 0.01 PER CENT ROTENONE SPRAY AS A CONTACT INSECTICIDE AGAINST *Aphis rumicis*. NO SPREADER

Spray	0.01 Per Cent Rotenone in 0.01 N Sodium Hydroxide Per Cent Kill	0.01 Per Cent Rotenone in Distilled Water Per Cent Kill	0.01 Per Cent Rotenone in 0.01 N Sulphuric Acid Per Cent Kill
Freshly made.....	71.2	93.4	93.9
After standing 2 days	75.4	96.0	92.3
After standing 8 days	38.7	79.9	67.0

Rotenone suspensions at concentration of 0.01 per cent in distilled water are milky white. The suspension made to 0.01 N with sodium hydroxide was less opaque and that with sulphuric acid more opaque than the approximately neutral distilled-water suspension. After standing twenty-four hours the rotenone in the acid suspension had settled almost entirely whereas in the neutral one no settling was observed over

a period of several weeks. Settling of the rotenone in the alkaline suspension was negligible. The behavior of the rotenone in the acid suspension leads one to believe that a similar settling from saponin suspensions is due to the acidity of saponin.

The results of the experiments with acid and alkali added to rotenone indicate that the toxicity of rotenone suspensions is not so easily affected in this manner as has been supposed. The addition of alkali seems to reduce toxicity more than does that of acid. However, an acid reaction of the spray brings about either larger particles or a clotting of the particles of rotenone so as to make them settle out. Hence it seems probable that rotenone suspensions are most stable if maintained as nearly neutral as possible.

The data in Tables 3 and 4 indicate that over a period of several weeks there is a rather gradual reduction in toxicity of all the rotenone suspensions used. However, spreader conditions interfere with the results and the range of acidity and alkalinity is not so great as in the suspensions used to obtain the data given in Table 5, so the indication of reduced toxicity is all that can be concluded from these data.

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THE TOXICITY OF ACID LEAD ARSENATE TO THE LARVA OF THE COLORADO POTATO BEETLE

By CHARLES H. RICHARDSON and LOUISE E. HAAS, *Department of Zoology and Entomology, Iowa State College, Ames, Ia.*

ABSTRACT

The estimated median lethal dose of acid lead arsenate for the Colorado potato beetle, *Leptinotarsa decemlineata*, larva of about 0.144 gram weight is 0.30 milligram per gram of body weight. The median lethal dose of Paris green was not closely estimated but is evidently less than one-third this amount. The consumption of food by the larva is less and the feeding time is shorter on poisoned than on normal food.

The recent papers by Campbell and Filmer[1] and Campbell[2] on quantitative methods for measuring the relative toxicity of stomach poison insecticides have prompted the writers to apply the method, with some modification, to a leaf-feeding coleopterous larva, the larva of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say). It has often been asserted that the larvae and adults of many species of Coleoptera are difficult to kill with arsenical compounds. The studies reported here were made in an attempt to throw some light on this subject.

MATERIALS. Larvae were gathered daily from potato plants and kept without food for 3 or 4 hours before they were used in the tests. The leaf "sandwiches", by means of which the arsenical was administered, were made from fresh potato leaves washed and dried between blotting paper before use.

The acid lead arsenate employed was a well-known commercial brand which gave on analysis, PbO 64.50%, As_2O_5 32.88%, water-soluble As_2O_5 0.22%.

METHOD. Disks 17 mm. in diameter were cut from potato leaves by means of a cork borer and kept in a moist chamber until needed.

A starch paste suspension of acid lead arsenate was made up to contain a known per cent by weight of the arsenate. The suspension was conveniently prepared and retained in tared 25 c.c. volumetric flasks; the starch paste used in making it contained about 3 grams of corn starch per 100 c. c. of suspension. Care was taken to obtain a smooth paste free from lumps.

The leaf "sandwiches" were prepared in the following manner: Two leaf disks were removed from the moist chamber and weighed in a tared

[1] A quantitative method of estimating the relative toxicity of stomach-poison insecticides. IV. Internat. Congress of Ent., Ithaca, August 1928, 2, 523–533 (1929).

[2] A comparison of four methods for estimating the relative toxicity of stomach poison insecticides. Journ. Econ. Ent., 23, No. 2, 357–370 (1930).

weighing bottle. By means of a camel's hair brush, the thoroughly mixed and shaken arsenate suspension was painted lightly and evenly upon the upper (smooth) surface of each leaf disk. The painted surfaces were then pressed gently together between blotting paper and the completed "sandwich" was weighed in a weighing bottle. The difference between the weight of the completed "sandwich" and the weight of the leaf disks represents the weight of the arsenate suspension. This value multiplied by the per cent of arsenate by weight in the suspension gives the quantity by weight of acid lead arsenate in the "sandwich."

The edge of the leaf "sandwich" was now presented to a previously weighed larva, sandwich and larva being placed in an uncovered stender dish within a moist chamber to prevent loss of weight of the sandwich by evaporation of water during the feeding period.

The dosage of arsenate which the larva obtained was varied by utilizing starch suspensions which contained different proportions of the arsenate and by varying the time of feeding of the larva.

After the requisite portion of the sandwich was eaten, the larva was removed from the moist chamber for observation at room temperature. The survival time of the larva was compared with that of control larvae fed upon unpoisoned foliage. As the mortality among the controls was negligible their records are not included here.

The remnant of the sandwich was again weighed in a weighing bottle. Difference in weight between the complete and the partially eaten sandwich represents the quantity ingested by the larva. The quantity of the acid lead arsenate ingested by the larva in milligrams is calculated from the proportion: $\frac{\text{Mg. PbHAsO}_4 \text{ in complete sandwich}}{\text{Weight of sandwich in grams}} = \frac{x}{\text{Quantity of sandwich eaten in grams.}}$ From the value for x and the weight of the larva, the quantity of $PbHAsO_4$ eaten in terms of milligrams per gram of body weight may easily be obtained.

Results with Acid Lead Arsenate. The results obtained with acid lead arsenate are given in Table 1.

Chief interest is attached to the central portion of the table in which dosage and survival time are given for larvae weighing 0.131 to 0.159 grams. The mean dosages 0.29 mg./g. and 0.31 mg./g. are shown from statistical analysis by the method of Fisher for the difference of means[3] to be significantly distinct from mean dosage 0.50 mg./g. but not dis-

[3]Fisher, R. A. Statistical Methods for Research Workers 2nd. Ed. XI + 269 p. London 1928.

TABLE 1. TOXICITY OF ACID LEAD ARSENATE AND PARIS GREEN TO LARVAE OF LEPTINOTARSA DECEMLINEATA.

Material	No. Larvae	Wt. of Larvae in Grams			Dose of Arsenical in Mg. per g. Body Wt.			Survival Time in Hours		
		Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.
Acid lead arsenate	10	.074	.108	.129	.25	.55	.87	3	4	10
	2	.118	.122	.125	.18	.42	.66	21	22.5	24
	3	.110	.115	.124	.09	.19	.34	24	—	66
M. L. D. 30	27	.131	.142	.158	.14	.50	.86	1.5	5	10
	12	.133	.144	.159	.11	.29	.52	12	34	98
	9	.137	.148	.156	.14	.31	.87	Recovered		—
	4	.161	.166	.177	.11	.22	.32	8.5	18	27[1]
Paris Green	5	.131	.145	.160	.10	.37	.69	1	6	10
	6	.130	.148	.178	.01	.05	.10	16	51	108[2]

[1]Time based on 3 larvae; the fourth recovered.

[2]Time based on 5 larvae; the sixth recovered.

tinct from each other. If the mean of these latter doses is taken as the best estimate of the median lethal dose (M. L. D.) the value 0.30 is obtained.[4] This is about 3 times the M. L. D. found for the fourth instar larva of the silkworm (*Bombyx mori*. L.)[1]

The difference between the toxicity of acid lead arsenate for the larva of the silkworm and for that for *L. decemlineata* is probably due in part to errors in method and in part to causes that lie in the greater vigor of the latter insect. One source of error which cannot easily be avoided results from regurgitation by the insect of a portion of the contents of the digestive tract shortly after feeding upon the poison sandwich. The quantity of solution regurgitated and time of ejection are quite variable and no estimate has yet been made of the quantity of arsenate lost in this way. That some of it has already affected the insect is indicated by the foregoing observations.

The 67 larvae which fed upon the sandwiches containing acid lead arsenate stopped eating within 3 to 24 minutes, the mean feeding time being about 10 minutes. During the feeding period they ate 46 mg. to 247 mg. of poisoned food, the mean quantity being 132 mg. Twenty-three larvae which were offered sandwiches containing starch paste but no acid lead arsenate fed from 5 to 82 minutes, mean time 37 minutes, and ate 89 mg. to 616 mg. of food, the mean being 344 mg. Evidently the presence of acid lead arsenate significantly reduced the time of feeding and the quantity of food ingested. The arsenate taken into the digestive tract during the first few minutes of feeding probably initiates the toxic action and the dosage received by the close of the feeding period has already definitely contributed to the poisoning of the insect.

It is probable that much of the so-called repellent effect of arsenical compounds on insects is in reality incipient poisoning with accompanying loss of appetite.

Another source of error results from the feeding habits of the larva. To obtain quantitative results, the larva should consume equal quantities of the upper and lower leaf disks together with the intervening arsenate suspension. This it does not always do but instead may devour more of one disk than of another and at times may eat a hole directly into the upper layer. Efforts to force these larvae to feed from the edge of

[4]The mean, 0.31 of the last series in the group under discussion is influenced by the presence of a single value, 0.87, which is more than twice as large as the next lower value in the series; i. e. 0.41. If this value is removed the mean of the remaining eight values is reduced to 0.24 and the standard deviation from 0.23 to 0.09. The M. L. D. then becomes 0.26. 0.87 is exceeded by plus 3 times the standard deviation, 0.23, and for this reason is retained.

the sandwich usually result in their refusal to feed at all. In the case of such irregular feeding it was assumed that the half of the starch paste filler adjacent to the disk was consumed with the disk substance, i. e. if the entire upper leaf disk were consumed then the upper half of the starch paste filler would be removed with it.

PARIS GREEN. A few tests were made with Paris green, the data for which are given in Table 1. Analysis of the sample used in the tests showed the following: CuO 38.84%, As_2O_3 54.75%, water-soluble As_2O_3 3.00%. Before making up the suspension, the Paris green was ground in a mortar, but the particles were still larger than those of the acid lead arsenate.

Although the M. L. D. cannot be fixed with certainty from so few tests, evidently it is less than 0.10 mg./g., and therefore not greater than 1/3 the value given above for acid lead arsenate. The feeding time was also shorter in this series, ranging from 2 to 25 minutes, the mean being 6 minutes. The quantity of food consumed was also less, the range being 32 to 223 mg., the mean 102 mg.

REFINED PINE TAR OIL FOR ORCHARD AND GARDEN USE

By E. R. DEONG, *Consulting Entomologist, San Francisco, California*

ABSTRACT

Pine tar oil, produced by the destructive distillation of pine wood, is now being used in the refined form as in insecticide and fungicide. This oil is used alone or in combination with nicotine for the control of aphids, thrips and similar types of insects. Pine tar oil has greater fungicidal value than petroleum oil and also may act as a carrier for copper resinate, which it dissolves readily. The combination of pine tar oil and copper resinate may be added to petroleum oil and the blend emulsified in the usual way.

The use of pine tar oil as an insecticide on plants has long been known to entomologists but on account of the tendency to injure foliage has never become common. The raw pine tar oil fractions with a high content of organic acid is, from the standpoint of plant injury, comparable to the unrefined petroleum distillate. Recent developments in the factory process of treating certain of the pine tar distillates to eliminate such danger has now placed them in a promising field for usefulness, not only as an insecticide and fungicide but also as a carrier for other active chemicals as nicotine and oil and water soluble metallic salts.

Pine tar oils are chemically complex compounds produced by destructively distilling "fat" pine wood. In their crude state, pine tar oils have a specific gravity of approximately 1.03 at 15.5° C with a boiling range

from approximately 85° C up to their start of break down point of approximately 250° C. When these crude oils are fractionated and refined, they produce various finished products, such as turpentine, refined tar oils, pine oils and pine tars. For this work, after long study and based on many tests, we have selected a refined pine tar oil which can be produced in good volume. This base oil has a specific gravity of from .90 to .92 at 15.5°C., with a boiling range from approximately 100° C to 230° C. This oil has been processed to remove organic acids and to prevent the development of such through oxidation, the resulting product being "Palustrex", on which the following tables are based.

THE TREATED REFINED PINE TAR OIL—PALUSTREX. The raw pine tar oil, as distilled, contains a small percentage of organic acids which, when applied to tender foliage, causes injury. Such injury may not appear immediately after application, but develops within a week or ten days after the application, manifesting itself in the form of discolored or dead spots on the leaves. Such injury is probably the result of the formation of additional amounts of organic acids through oxidation of the oil present in the leaf structure.

The danger to foliage, as described above, both of the delayed and immediate type, resulting from the use of raw pine tar oils, has been checked through special processing at the factory. This treatment not only neutralizes the acid normally present in the raw oil, but retards the development of more acid through oxidation. It has also been found that higher concentrations of nicotine may be secured in such treated oil than is possible in the raw distillate. Palustrex contains but a trace of tar and even in the water soluble form has no uncombined rosin, thus making possible its use on foliage without a "varnishing" effect.

TREATED PINE TAR OIL AS AN INSECTICIDE. The value of oils as insecticides depends not only on their toxic action on or in the body of the insect but also on their physical attributes. The latter, which are of particular value for spray applications are penetrability through minute openings, wax solvency and low surface tension. Through these properties it is possible for oil, and some oil emulsions, to penetrate into the minute breathing pores of insects, instead of touching only the surface of the insect's body; partially or wholly dissolve the waxy surface of the insect body and leaf, thus facilitating coverage; and also through low surface tension, oils are capable of spreading over solid surfaces to a much greater degree than is water, when used as a carrier for insecticides.

Fine tar oil shows the above physical qualities and, in addition, has the distinctive values of fungicidal action superior to the highly refined

petroleum oils; greater activity usually as a solvent for other toxic chemicals and is more easily emulsified than many petroleum oils.

Specially treated pine tar oil, containing but a trace of tar, offers especial promise for use on active plants. It is easily made in a water soluble form and makes a good insecticide for aphids, thrips, larvae and the very young stage of scale insects at dilution of 0.5 to 1 per cent concentration. It is also very fine for combining with free nicotine at decidedly lower concentrations than where nicotine is combined with soap and water.

Pine tar oils, such as Palustrex, are decidedly volatile, evaporating quickly from the leaf surface and being readily translocated when in the leaf structure. On account of their volatility, they are not recommended for use alone on resistant scale insects and eggs but should be combined with petroleum oil. The usual proportions are 5 to 12 per cent of Palustres with refined petroleum distillates as illustrated in Table 1. Such combinations may, if desired, also carry dissolved nicotine or other active insecticides and also copper resinate. The latter form is suggested where aphids and other insects are present together with fungus diseases. Treated pine tar oil and petroleum distillates may be combined directly and then emulsified and diluted as customary for use as a dormant or foliage spray against scale insects, insect eggs, etc., and as a foliage spray. The type of petroleum being varied with the use. Such combinations have shown increased insecticidal value, in some of our experiments, greater solvency for certain chemicals and fungicidal value superior to that of the refined lubricating oil.

The water soluble form of the treated pine tar oil is usually combined with nicotine or copper resinate or both. Nicotine is usually present in sufficient concentration so that complete kills of aphids are common at a dilution of 0.02–0.03 per cent nicotine in the dilute spray in comparison with 0.05 per cent nicotine commonly used with water as a carrier. The rose aphis has been controlled at even lower dilutions than the above, under favorable field conditions. If fungus diseases are present then the inclusion of copper resinate at 15.0 per cent by weight gives a good dual purpose spray for aphids, larval stage of scale insects and certain caterpillars. Dilutions of the water soluble pine tar oil of 1 to 100 have caused no injury on apple, pear, peach and beet foliage at high humidities and maximum temperatures up to 88° F. The only injury noted at the 1–100 dilution was on the growing tips of peach and at a maximum temperature above 100° F. The water soluble pine tar oil containing sodium should not be used in combination with lead arsenate. Alkalis and strong concentrations of copper sulfate also throw the oil out of solution. Emul-

sions of the treated oil are being prepared that will overcome the above difficulties.

TABLE 1. COMPARATIVE TOXICITY OF RAW AND TREATED PINE TAR OIL AND PETROLEUM OIL TO MEALY BUG[1]

Oil Used[2]	Per Cent Kill
Raw Pine Tar Oil	86.4
Treated Pine Tar Oil	95.9
Petroleum Oil (Viscosity 80 seconds, unsulfonatable residue 90%)	87.6
Petroleum Oil, containing Treated Pine Tar Oil 3%	92.8
Petroleum Oil, containing Treated Pine Tar Oil 6%	93.9
Petroleum Oil, containing Treated Pine Tar Oil 9%	95.7
Petroleum Oil, containing Treated Pine Tar Oil 12%	96.9

[1]*Pseudococcus gahani* Green.
[2]All oils emulsified and used at 2% concentration in diluted spray.

NICOTINE AND COMBINATIONS OF TREATED PINE TAR OIL. The treated oil is particularly active as a solvent for other chemicals. This property has been studied especially with regard to the alkaloid nicotine, as shown by the following data: It should be noted that this work is with "free" nicotine and not a combined form with an acid, such as nicotine sulfate. The solubility of the treated pine tar oil for rotenone, the active principal in the plant Derris and "Tuba", is also being studied. Should such a combination be found possible it would offer the means of incorporating definite concentrations of rotenone directly into the petroleum oil and emulsifying the latter as desired.

Nicotine, in a 95 per cent concentration, enters readily into solution with treated Pine Tar Oil which is practically anhydrous, as shown in Table 2. This oil, in the original state, contained but 0.02 per cent moisture, but even this slight amount retarded solubility to a certain extent. The nicotine contained slightly over 2 per cent moisture, but this did not alter the solubility to any great extent, as will be shown later when checked against a nicotine of 98.8 per cent purity.

TABLE 2. SOLUBILITY OF NICOTINE, NINETY-FIVE PER CENT CONCENTRATION, IN ANHYDROUS[1] PINE TAR OIL

Treated Pine Tar Oil by Volume	Nicotine 95% by Volume	Nicotine 95% by Volume	Result Observed
cc.	cc.	%	
5.0	0.1	1.86	Soluble
5.0	0.5	8.64	"
5.0	1.0	15.8	"
5.0	2.5	31.7	Nicotine separated
5.0	5.0	47.5.	Soluble
5.0	10.0	63.3	"
1.0	10.0	86.4	"

[1]This fraction containing 0.02 per cent moisture was dried over calcium chlorid to approximately anhydrous condition.

The concentrations as shown in Table 2 were placed in test tubes and allowed to stand for several days before final observations were recorded. As the quantity of nicotine was increased no separation took place until the concentration was 31.7% of the total by volume. At this point there was a distinct lower layer of about 0.2 cc. of nicotine. As the concentration of nicotine is increased up to 86% the two are again perfectly soluble. This phenomenon of solubility is similar to the solubility curve of nicotine and water.

The direct relationship between moisture content and solubility of the treated pine tar oil and nicotine is shown in Table 3, where graduated amounts of water are added to the oil before agitating with the nicotine. Even 1 per cent of moisture, on the basis of pine tar oil present, is seen to be undesirable while 3 per cent causes a rapid separation. A practical confirmation of this principle is found in the difficulty of combining free nicotine containing large amounts of water as compared with 95 per cent free nicotine. The higher concentration requires more care in handling but is preferred for factory purposes.

TABLE 3. SOLUBILITY OF NICOTINE, NINETY-FIVE PER CENT. CONCENTRATION OF TREATED PINE TAR OIL WITH VARYING ADDITIONS OF MOISTURE

Treated 50% Pine Tar Oil 50% Nicotine (95%)	Water Added to Oil	Amount of Water in Oil	Results Observed
cc.	cc.	%	
10	.05	1.0	Slight Turbidity
10	.10	2.0	" "
10	.15	3.0	Drops separate
10	.20	4.0	" "
10	.25	5.0	" "
10	1.00	20.0	2.5 cc separate

The same difficulty in obtaining a solution in the presence of large amounts of moisture is shown in Table 4 to exist in combinations of treated pine tar oil, nicotine and refined petroleum oil. A true solution resulted up to 0.48 per cent nicotine and partial solution of 4.32 per cent nicotine, but separation into layers resulted at 7.91 per cent and oil and

TABLE 4. SOLUBILITY OF TREATED PINE TAR OIL AND NICOTINE, NINETY-FIVE PER CENT CONCENTRATION, IN REFINED PETROLEUM OIL[1]

Mineral Oil by Volume	Treated Pine Tar Oil and Nicotine	Nicotine by Volume	Water by Volume	Result Observed
cc	cc	%	cc	
10	.04	.19	—	Soluble
10	.10	.48	—	"
10	.50	2.27	—	Cloudy
10	1.00	4.32	—	"
10	2.00	7.91	—	Two Phases
10	3.00	10.95	—	" "
10	.04	0.19	.02	Drops separate

[1]Viscosity 95 seconds Saybolt at 100-F. Sulfonatable value 96 per cent.

nicotine separated out with the addition of even 0.02 per cent water. In other experiments, it was found that a nicotine solution of a 98.85 per cent concentration gave a concentration of nicotine in the petroleum-pine tar oil mixture of 16.5 per cent before separation took place.

It is concluded from these data that the highest concentration of nicotine consistent with economy and safety of handling should be used in all such combinations of nicotine and oil. Solubilities of treated pine tar oil and other chemicals have not been studied as thoroughly, but it is suggested that the concentration of moisture is a factor which may also be important in other fields of research.

Practical trials of the above solubility data show the possibility of combining nicotine (95 per cent concentration) with dry, treated pine tar oil in all proportions experimented with and without separation on standing, except at an intermediate stage. The latter being determined only at one point as 31.7 per cent as shown in Table 2.

A commercial type of soluble pine tar oil containing 12 per cent actual nicotine, as an example of a highly concentrated oil-nicotine combination has given satisfactory results, both from the standpoint of toxicity as an insecticide and in plant tolerance. This mixture has given practically 100 per cent kills on aphids at a dilution containing 0.02 to 0.03 per cent nicotine in dilute sprays. Greater efficiency has also been shown on the larval stage of the bean thrips larvae than when similar concentrations of nicotine are applied with water as a carrier. No injury was noted on peach and apple foliage at dilutions of 1 to 100 and in temperature of 92° F.

The value of pine tar oils and nicotine in the control of Pear Psylla has recently been shown by Hartzell[1].

Fungicidal Value of the Treated Pine Tar Oil. A large series of experiments have been made on the fungicidal value of treated pine tar oil alone and combined with copper, in comparison with various fractions of refined petroleum oils. The latter are generally recognized as low in toxicity from the fungicidal standpoint when refined to a value of 90 per cent or more, unsulfonatable. Oils of a lower degree of refinement are more active as fungicides but dangerous to plants. The data in Table 5 is a summary of many experiments using the spores of the Brown Rot Fungus Monilia and a vegetable decay fungus Botrytis. These experiments were made in what is known as the "hanging drop culture." The spores were suspended in a two per cent emulsion of the respective oils which were held at a pH value of 4.9. Germination counts of the spores were made at 48 hour exposures.

[1]Hartzell, F. Z. Jour. Econ. Ent. 23:190–197.

TABLE 5. FUNGICIDAL VALUE OF TREATED PINE TAR OIL AND REFINED PETROLEUM OILS

No.		Emulsion Concentration	Monilia Spores Germination Per Cent	Botrytis Spores Germination Per Cent
		%	%	%
1	Petroleum Oil[1]	2	40.1	33.2
2	Petroleum Oil plus 2% Treated Pine Tar Oil	2	23.0	31.0
3	Treated Pine Tar Oil	2	34.2	25.9
4	Soluble Treated Pine Tar Oil	2	0.4	5.5
5	Soluble Treated Pine Tar Oil plus copper	2	0.0	0.2
	Check		82.0	88.1

[1]Viscosity 90. Unsulfonatable value 96%.

The oils in Nos. 1–3 inclusive were emulsified with calcium casein, while Nos. 4 and 5 were made water soluble at the factory. The two groups were run on different lots of spores which would account for some difference in results, but even so, the soluble forms seem better adapted to fungicidal value than those emulsified with casein, possibly a more uniform mixture was obtained with the soluble oil.

Combinations of water soluble treated pine tar oil and copper resinate or pine tar oil, copper resinate and petroleum are suggested for dormant spraying.

ADDITIONAL INSECTICIDAL VALUES. Dormant applications of soluble tar oils to the trunk and larger limbs of the apple tree have been suggested by Dr. T. J. Headlee[2] as an additional protective measure in codling moth campaigns. For this purpose, an oil with a specific gravity of about 1.025–1.035 is recommended. Another fraction, of greater penetrative powers, is also suggested for such work. The specific gravity is about 0.910–0.915. The end point on the distillation range of this fraction is about 235° C. Such oils may also carry copper in solution, thus adding a decided fungicidal value to their usefulness as a dressing for cankers.

The repelling value of pine tars and other distillation products has already been stressed by Bishopp[3] in his studies of the control of the screw worm fly, so no further attention will be given this subject.

It should also be noted that the lighter fractions of pine tar oils have found use in fly sprays as a supplement to kerosene, the solvent powers of the pine tar oil making possible a greater range of additional toxic materials than is possible with kerosene alone.

[2]Headlee, T. J., Jour. Econ. Ent. 22:89–97.

[3]Bishopp, F. C., Jour. Ec. Ent. 16:222–224 and 18:776–778.

SUMMARY

Treated pine tar oil, prepared especially for use on the growing plant, has been found to be an active insecticide. Distillates containing appreciable amounts of tar should not be used, nor the raw distillate, as the latter may contain a dangerous amount of organic acid, which may increase by natural oxidation.

Nicotine, in the free state, is readily soluble in treated pine tar oil, thus increasing the toxicity and also retaining the physical value of the oil.

Soluble pine tar oil is desirable from the standpoint of control of aphids, thrips and the young stage of the unarmoured scale.

The fungicidal value of pine tar oil is decidedly superior to that of refined petroleum oils and, by the inclusion of copper, gives both an insecticidal and fungicidal value.

A combination of treated pine tar oil and copper resinate with lubricating oil gives an active insecticide and fungicide that offers certain advantages over petroleum oil-Bordeaux sprays.

A PRELIMINARY REPORT ON THE INSECTICIDAL PROPERTIES OF DEVIL'S SHOE-STRING, *CRACCA VIRGINIANA* LINN.[1]

By V. A. LITTLE, *Associate Professor of Entomology, Texas A. and M. College, College Station, Texas*

ABSTRACT

Possibilities for the development of a fish-poison for insecticidal purposes are found in Devil's shoe-string, *Cracca virginiana* Linn., an American plant. Aqueous suspensions of the powdered roots compare favorably in toxicity with derris, pyrethrum and nicotine sulphate (40%). Field experiments show the insecticide to be efficient in the control of a number of insects, especially animal parasites.

Interest in the possibilities of Devil's shoe-string as an insecticide was aroused through studies of derris, and particularly through the physiological action of derris on fish. Devil's shoe-string is a powerful and effective fish-poison, and from accounts of its action, and that of derris, they affect fish in a similar way. Before the passage and enforcement of fish and game laws, Devil's shoe-string was widely used in east Texas and other southern states as well.

Only the roots were used for this purpose. They were pounded up and then placed in sacks, and churned up and down in streams where the current was swift enough to effect a quick and thorough mixture of the

[1]Contribution No. 22, Department of Entomology, Texas A. and M. College, College Station, Texas.

toxic properties of the plant with the water. The fish came to the surface in a few minutes and could easily be caught. The effectiveness of the poison is evidenced from reliable reports that cat fish weighing more than thirty pounds were caught, and fish came to the surface as far as one-fourth mile down stream. There is no information available as to whether or not fish affected recovered. This would probably depend on the dosage of poison, the kind and size of fish.

Through experience it was learned that the best results were obtained during the summer months. It was thought that this was due to the smaller volume of water at that season of the year. As a result of our studies of this plant, we are of the opinion that along with this factor it is most toxic at that season. Toxicity of the plant is variable and this was noted here also, as better results were obtained at some times than at others.

Cracca is a large genus of plants belonging to the pea family, *Fabiaceae*, and it is widely distributed, but is confined chiefly to the tropical and subtropical regions of the world. Small lists seventeen species. The distribution of this particular species is given by the same authority as Ontario to Manitoba, Florida, Texas, and Mexico. We have found it to be widely distributed throughout east Texas and as far west as east central Texas. The roots are long and fibrous, attaining a length as great as five feet, and the diameter ranging up to five-eights inch with an average of about one-fourth inch. They are yellowish in color and have a very characteristic odor.

Review of Literature. Pammel reported that *Cracca* (*Tephrosia*) *virginiana* was used as a fish-poison by the Indians, and he also lists it as an arrow poison. There are no references in literature where this species has ever been used for insecticidal purposes or where any chemical studies have been made of it, however some investigations have been made of other species of this genus, namely: *Cracca* (*Tephrosia*) *vogelii*, an African species; *Cracca* (*Tephrosia*) *toxicaria*, a South American form; *Cracca* (*Tephrosia*) *candida*, material collected in the West Indies, a widely distributed form; *Cracca* (*Tephrosia*) *macropoda* and *Cracca villosa purpurea*, a Pacific fish-poison.

Aders (1916) used the leaves of *C. vogelii* in some tests on mosquito larvae. Two U. S. patents, 1242954 and 1242955, were issued to Lemmens and Fryer covering the uses of this genus as an insecticide and sheep dip in combination with a sulphur soap, and extracts containing benzine, alcohol and soap. Fryer, Stenton, Tattersfield and Roach (1923) found that the seeds of *C. vogelii* had a measure of toxicity to silk

worms. McIndoo and Sievers (1924) reported negative results with *C. villosa purpurea*. Smee (1926) used crushed leaves of *C. vogelii* in soapy water to control thrips on coffee.

The only insecticidal studies of any importance were made by Tattersfield, Gimingham and Morris (1925, 1926, 1928). They first worked with extracts of *C. vogelii; Aphis rumicis* was used in their tests. The most toxic parts of the plants were the leaves and seeds. Encouraging results were obtained. They later worked with extracts of *C. toxicaria* and *C. candida* in addition to those of *C. vogelii*. They found the roots of *C. toxicaria* and the leaves of *C. vogelii* to be of the same order of toxicity. *C. candida* had little insecticidal value. Tests on caterpillars with extracts of *C. vogelii*, *C. toxicaria* and *C. macropoda* as stomach poisons showed that the plants were powerful repellents but of no positive insecticidal value.

A chemical analysis of the leaves of *C. vogelii* was made by Hanriot (1907) in which he isolated three compounds, tephrosin, $C_{31}H_{26}O_{10}$, tephrosal, $C_{10}H_{16}O$, and a yellow crystalline material. Some chemical studies were also made by Tattersfield, Gimingham and Morris on *C. vogelii* and *C. toxicaria*, and the crystals and resin obtained were tested out on *Aphis rumicis*. Clark (1930) isolated two products from *C. toxicaria*, toxicarol, $C_{23}H_{22}O_7$, and deguelin, $C_{23}H_{22}O_6$. He also stated (1931) that deguelin is present in the leaves of *C. vogelii*. Davidson (1930) published a study on the relative toxicity of rotenone, deguelin, tephrosin, and toxicarol, all of which, however, were isolated from derris.

Experimental Methods. The purpose of these investigations was: (1) to obtain data on the comparative toxicity of Devil's shoe-string with that of derris, nicotine sulphate (40%) and pyrethrum; (2) to learn something of the types of soil and the seasons that produce the most toxic samples; (3) to study the effects of different methods of drying the roots, the effects of heat, of storage and of prolonged soaking in water; (4) to study the physiological effects on insects; and (5) to test the product under field conditions upon as many different insects as possible.

Plants were dug from some half-dozen localities, and in one case a fairly complete collection was made at different intervals over a period of one year. Part of the samples were sun dried, some were dried in the shade while one sample was dried in an improvised oven. They were then ground in an herb mill and the product put through a hundred mesh screen. The samples of derris and pyrethrum used had some advantage in that they were more finely divided. The species of *Deguelia* (*Derris*) used was not known but it was probably *D. elliptica*. Preliminary tests on house flies with the freshly dug roots showed there was apparently

little difference in the toxicity of undried and properly dried samples. With the exception of some preliminary tests with extracts, all of the laboratory tests were made with suspensions of the powder in water. Tests with the leaves and stems of the plant showed little or no effect on house flies.

The cotton or melon louse, *Aphis gossypii*, was the insect used in the major part of the work. It proved to be quite satisfactory for several reasons. It is easily reared in large numbers on cotton, and it crawls about very little when conditions are satisfactory. Cotton leaves retain their succulency for a long time under proper conditions and the nature of the leaves is such that a very uniform distribution of spray may be obtained. The infested leaves were fastened to the drum of a kymograph that revolved in a spray box. The spray was delivered by a De Vilbiss No. 28 atomizer with a constant air pressure of fifteen pounds. After the leaves were sprayed, the stems were put into vials of water and placed on sheets of paper on the laboratory tables. Aphis counts were made after the lapse of forty-eight hours. The heat from a sixty Watt lamp was used in separating the live aphids from the dead ones. The experiments were repeated a number of times in order to lessen the experimental error due to fluctuations in temperature and humidity, varying percentages of adults on the leaves, the birth of young lice from adults that might not be killed, and possible other factors entering into the complex. The air in the laboratory was kept in circulation by an electric fan. Careful records on temperature and humidity were made by the use of a standard hygrothermograph. The average mean temperature for all experiments was 74.2° Fahrenheit unless otherwise stated, while the average mean relative humidity was 61%.

About seventy thousand lice were used in the tests of which about eleven thousand were used in the controls. An average of one-hundred and eighty-six were used in each experiment. The mortality of the controls where no spreader was used was 18.5% and that of the controls where soap was added to the spray was 26.7%. Spreaders were used only in a few tests. In these tests one-fourth of 1% potash fish oil soap was added to the spray. Dilutions of one to eight hundred were used in all but a few experiments. This gave a percentage of kill quite satisfactory for comparative purposes.

The experiments on house flies were not as exhaustive as those on plant lice. They were used as a check on the accuracy of the results obtained on the lice, and being more resistant insects, to bring out more distinctly differences in toxicity. The flies were reared in the departmental insectary and were not used until they were five days old.

About fifteen flies were used in each experiment. They were put in small cone-shaped screen cages for treatment and were sprayed in somewhat the same manner as the plant lice. The dosage used was one part of the insecticide to one hundred parts of water. After spraying the flies were immediately transferred to larger cages. Counts were made at the end of 48 hours. The mortality of the water controls was 1.3%. The average mean temperature during the experiments was 87° F. and the relative humidity was 56.4%.

EXPERIMENTAL DATA. Table 1 shows the comparative strength of a number of samples of Devil's shoe-string with samples of derris, commercial brands of pyrethrum and nicotine sulphate; and it also shows variations in the toxicity of the plant. It will be noted that the order of toxicity of the most effective samples was the same on both plant lice and house flies but the results with the weaker samples were somewhat erratic. Nicotine sulphate proved to be the most toxic, but it is probably an unfair comparison due to differences in physical forms. The next

TABLE 1. VARIATIONS IN TOXICITY OF SAMPLES OF DEVIL'S SHOE-STRING AND ITS COMPARATIVE TOXICITY WITH DERRIS, NICOTINE SULPHATE, AND PYRETHRUM

Dosage 1 to 800—no spreader.

Insecticide	No. of Sample	*Aphis gossypii* No. of Experiments	*Aphis gossypii* Calculated % of Kill	*Musca domestica* No. of Experiments	*Musca domestica* Calculated % of Kill
Nicotine Sulphate (40%)		8	96.4	–	—
Derris	47	8	89.4	4	85.3
"	11	8	88.2	4	81.2
"	48	8	87.2	4	78.2
Shoe-string	50	8	82.2	–	—
"	51	8	81.8	–	—
"	19	14	80.7	4	74.3
"	49	8	80.6	–	—
"	42	8	80.4	5	66.6
Pyrethrum		7	80	–	—
Shoe-string	8	8	75.8	5	44.5
"	25	8	69.3	4	5.4
"	27	8	61.8	4	13.7
"	1	8	61.6	–	—
"	44	4	56.1	–	—
"	34	8	51.	–	—
"	4	8	19.9	4	5.4
"	5	8	18.2	4	5.4
"	46	8	16.8	4	7.6
"	41	8	0.7	4	3.6
"	40	8	0	2	4.7

three most toxic samples were the samples of derris. Nos. 19, 49, 50 and 51 represent four samples of shoe-string dug from the same locality during the latter part of July and August in a uniformly poor sandy soil along the western limits of the distribution of the plant in Texas. The next best sample, 42, found in poor sandy soil, was dug in east Texas in

August. The difference between the results of derris and nicotine sulphate is greater than the difference between the best samples of shoestring and derris.

Something can be learned of the seasonal variation of the toxicity of the plant through a study of the results with samples 5, 27, 44 and 46, 1 and 4, and 8, 19 and 51. The first four were collected in the same place and they were all dried in the sun except No. 46, which through mistake was dried in the shade. The most toxic sample 27 was dug July 23. The weakest are 5 and 46. No. 5 was dug in June and 46 in December. If No. 46 had been properly dried it probably would have proved more toxic. The second most toxic sample, 44, was dug September 14. Samples 1 and 4 represent roots dug in September and May from another locality. The fall sample was decidedly the most toxic. Numbers 8, 19, and 51 represent samples from a third locality. No 8 was dug July 4, No. 19 July 24 and No. 51 August 23. Nos. 19 and 51 are about the same rank in toxicity and both are more toxic than No. 8. No. 51 probably would have proved more effective had it not been partially dried in the shade due to rainy weather. Nos, 49 and 50 were dug on July 24, one year later. The results with these two samples, compared with 19, would at least indicate little variation from year to year.

That the age of the plants and the soil are important factors are indicated in samples 25, 34, 40 and 41. They were dug from July 23 to August 11. Nos. 34 and 41 were dug the same day from the same locality, but the roots of 34 were from larger plants than 41. The difference in toxicity may however be due to different varieties. Nos. 40 and 25 represent samples from clay soils. Variations in toxicity due to the time of the year, soil, probable difference in varieties, and perhaps temperature, rainfall, hydrogen ion concentration, drainage, shade, and even other factors produce a complex that will take considerable work to solve. In general, all that can be said is that the most toxic samples are from poor sandy soil and that the toxicity is lowest during the winter and spring, and highest during the hottest part of the year.

Table 2 shows the effects of different methods of drying, storage, soaking and boiling in water. Drying is an important factor. This is shown in the results of samples 19, 20, 30, 32, 42, and 43. Nineteen and 20 were of the same collection but 19 was sun dried while 20 was dried in the shade. Thirty and 32 represent another collection, and 40 and 43 a third. In two of the three cases the differences in toxicity is outstanding, and in every case the sun dried samples are more toxic. Sample 26 is the same as 19 but was dried in an improvised oven. The same results were obtained as in the boiled sample.

TABLE 2. EFFECTS ON *Aphis gossypii* OF DIFFERENT METHODS OF DRYING, STORAGE, HEAT AND SOAKING OVER-NIGHT IN WATER. DOSAGE 1 TO 800—NO SPREADER

Number of Sample	Number of Experiments	Calculated % of Kill
2A	8	46.6
2B	8	37.9
18	8	80.2
18 (Soaked)	8	68.6
18 (Boiled)	4	72.5
19	14	80.7
20	8	53.5
26	4	75.5
30	8	69.4
32	8	62.3
42	8	80.4
43	8	22.5

Something of the effects of storage is shown in samples 2A and 2B, and 18 and 19. 2A and 2B represent samples from the same collection of roots; 2A was put in a sealed bottle and 2B was kept in an unstoppered wide-mouthed bottle. They were kept on the shelves of an open cabinet in the laboratory for twenty months before they were tested. The results show a slow but a definite deterioation in 2B. Sample 18 was not ground until ready for use but the roots were kept in a cupboard in the laboratory; 19 was ground as soon as dried and stored in a tightly closed container. There is little difference in their toxicity. Soaking and boiling in water cause a loss in toxicity. The soaked sample was allowed to remain over-night in distilled water; the boiled sample was boiled in water for fifteen minutes.

Greater dilutions tend to bring out more distinctly differences in the relative toxicity of various poisons just as experiments at lower temperatures tend to show. On the other hand the use of spreaders and the use of the insecticides at greater concentrations will tend to show less marked differences. This is shown in Table 3. The data on the samples used at a dosage of 1 to 800 without spreaders is again listed for comparative purposes.

With dilutions of 1–3200 the differences in the toxicity of nicotine sulphate, derris (47) and shoe-string (19) show a tendency to be more pronounced. When experiments are run at lower temperatures the same tendency is shown as in samples 11 (derris) and 19 (shoe-string) when run at temperatures about 10° lower than normal. When soap was added as a spreader, the three insecticides tended to show less differences in toxicity, and at dilutions of only 1 to 400 with a spreader, the differences are still less marked. At this concentration, both derris and nicotine sulphate gave a 100% kill while shoe-string showed a kill of 94.8% which must certainly be considered commercial control. Experiments on turnip lice, *Rhophalosiphon pseudobrassicae*, under the same conditions gave kill of 93%.

TABLE 3. EFFECTS OF GREATER DILUTION AND CONCENTRATION, SPREADERS, AND LOWER TEMPERATURES ON *Aphis gossypii*

Insecticide	Sample Number	No. of Experiments	Dosage	Spreader	Calculated % of Kill
Nicotine Sulphate (40%)		8	1–800	No	96.4
Derris	47	8	1–800	"	89.4
Derris	11	8	1–800	"	88.2
Shoe-string	19	14	1–800	"	80.7
Nicotine Sulphate (40%)	8	8	1–3200	"	82.8
Derris	47	8	1–3200	"	73.1
Shoe-string	19	8	1–3200	"	64.3
Derris 64.5°F.	11	4	1–800	"	53.6
Shoe-string 64.5°F.	19	4	1–800	"	37.2
Nicotine Sulphate (40%)		12	1–800	¼% p. f. oil	99.4
Derris	47	12	1–800	soap	99.7
Shoe-string	19	12	1–800	"	91
Nicotine Sulphate (40%)		8	1–400	"	100
Derris	47	8	1–400	"	100
Shoe-string	19	12	1–400	"	94.8

PHYSIOLOGICAL EFFECTS. Devil's shoe-string kills in a similar manner to that of derris. Its action is as quick or even more so, but it takes a somewhat longer time for the insects to die. It kills through paralysis and perhaps also through interference with respiration. Observations on larvae of *Datana ministra* indicate that paralysis begins at the posterior end of the body and advances forward. As the abdomen becomes paralyzed the larvae bite at their spiracles much like mosquito larvae do after oil is poured on the water. The comparative death rate caused by shoe-string and derris is shown in the following experiments with the apple tree tent caterpillar, *Malacosoma americana*. Caterpillars ranging in size from one-third to two-thirds grown were dipped in solutions diluted at the rate of 1 to 400 for 20 seconds and then placed in cages on dipped foliage. Fifty caterpillars were used in each experiment and with each insecticide four experiments were run.

DAYS AFTER DIPPING LARVAE OF *M. americana*

Sample Number	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
11 (derris)	16	32	46	64	76	94	101	119	119	129	135
19 (shoe-string)	4	5	9	16	38	56	70	83	94	105	111

All of the larvae were affected but some recovered and resumed feeding. In order to learn if the effects were permanent, two experiments of each insecticide were carried through until the caterpillars had either died or had transformed to moths. From 100 caterpillars dipped in the derris spray, 14 pupated and 11 moths emerged, with 38 pupating and 34 moths emerging from the shoe-string experiments.

House flies become paralyzed in their legs and may fly about but drop wherever they try to alight. Death comes within the first two days. Fleas are generally affected within five or ten minutes. They first become wobbly on their feet and when the paralysis increases they drop from the host unless they are "sticktite" fleas. They generally die within 24 hours. In order to ascertain if fleas would recover from the effects of insecticide, seven cat fleas were picked from the floor after dusting a dog and placed in a glass tumbler. Attempts were made to feed them by placing them on the arm of the investigator. At the end of 24 hours all were dead except one, and it was kept alive for several days by propping it up so it could feed but it never recovered in the least from its locomotor paralysis.

Observations on apple tree tent caterpillars, *Malacosoma americana* and yellow necked caterpillars, *Datana ministra*, indicate that the plant has little or no value as a stomach poison but is quite repelling. There are no records of the plant being toxic to higher animals. Live stock apparently eat the foliage with relish, and cotton tail rabbits feed on the young tender leaves and stems. Dogs and cats will lick themselves with no ill effects after they are dusted. People are known to use the roots as tooth brushes; and fish poisoned with it are certainly not poisonous as human food. But if the toxic principle were to get into the blood stream it would probably prove quite toxic.

FIELD EXPERIMENTS. Seven colonies of apple tree tent caterpillars, *Malacosoma americana*, ranging in size from one-third to full grown were sprayed with an average sample of shoe-string, the dosage being at the rate of one pound to fifty gallons of water. Five of the seven colonies were completely destroyed. The caterpillars of the sixth colony that did not die in the first week after they were sprayed were attacked by ants and destroyed, while some of the larvae of the seventh colony apparently recovered and pupated.

Three colonies of yellow-necked caterpillars, *Datana ministra*, feeding on post oak were sprayed, the dosage being at the rate of two pounds to fifty gallons of water. The colonies represented three sizes, quite small, one-half, and three-fourths grown. The mortality was 100%.

Egg-plants heavily infested with potato beetle larvae, *Leptinotarsa decimlineata*, were thoroughly sprayed with a dosage of two pounds to fifty gallons of water. A control was run and counts were made at the end of the fifth day which showed a calculated kill of 96.8%.

Cotton infested with cotton or melon lice, *Aphis gossypii*, were sprayed with a dosage of 1 to 800. Plants were similarily sprayed with derris

and nicotine sulphate (40%). Counts made before and two days after spraying showed a kill of 98.2% for the shoe-string, 99.4% for derris and 99.7% for nicotine sulphate.

Twenty-seven experiments on fleas infesting cats and dogs were recorded. There were four species involved in the infestations: *Ctenocephalus felis*, the cat and dog flea, *Echidnophaga gallinacea*, the 'sticktite" flea, *Pulex irritans*, the human flea and *Holopsyllus affinis*. The first two species were in the great majority. The insecticide was applied as a dust and as a dip. The dusts used were diluted with equal parts of starch or undiluted. The dip was used at the rate of 1 to 800. The amount of dust used varied from two to four or more grams per animal. Perfect results were obtained in every case except in some instances in the control of the "sticktite" flea. Owing to its sedentary habits occasionally individuals were missed, and if a flea received only a light dosage, it might be paralyzed and still live on the host. Dusts were more satisfactory than dips. The insecticide proved to be active over a period of about three days. This was found by dusting a dog and taking it daily into a flea infested barn and observing the fleas that got on it. Several commercial flea powders were tested in comparison but none proved to be hardly as effective. Undiluted derris however proved to be more effective.

The powder proved to be effective in the control of the castor-bean tick, *Ixodes ricinus*, but neither it nor derris were satisfactory in the control of the brown dog tick, *Rhipicephalus sanguineus*. Laboratory tests on adults of the fowl tick, *Argas persicus*, showed that both shoe-string and derris were ineffective.

Shoe-string proved to be 100% effective against all lice experimented with. Six hens and two roosters infested with the fluff louse, *Goniocotes hologaster*, and the large hen louse, *G. gigas*, were dusted and put in a coop. One day later one live louse was found and it was in a paralyzed condition. At the end of the second day no live lice were found. A puppy infested with *Trichodectes canis* was dusted. An examination one day later failed to reveal any live lice. The powder was also reported to be effective against *Phthirius pubis* but it did not affect the eggs.

Encouraging results were obtained on cattle grubs, *Hypoderma lineata*. The grubs were located, dusted and a chart made of their position on the backs of the cows. Seven to ten days later they were extracted and examined. No attempt was made to determine the instars. Sixty-seven grubs were treated in the backs of 8 cattle. Of these 53 were dead, 6 alive and 8 doubtful. Counting the doubtful grubs as alive a kill of 79.1% was obtained, as dead 91%, would be had, and if not counted, a kill of 89.8% is shown.

Observations during the experimental work on the cotton aphis in the laboratory showed that shoe-string, with the dosages used, had no effect on syrphid fly larvae, probably *Syrphus americanus* and *Allograpta obliqua*. The eggs of the cotton leaf worm moth, *Alabama argillacea*, were not affected; red spiders, *Tetranychus telarius*, suffered only a light mortality, and nymphs of an unknown species of leaf-hoppers were not affected.

SUMMARY. Devil's shoe-string, *Cracca virginiana* Linn., is an American fish-poison that compares quite favorably as an insecticide with derris and other insecticides as shown in these experimental data. The toxicity of the plant varies greatly, depending on the season, soil and possibly many other factors. The method of drying the roots, heat and soaking in water affect the toxicity. Field experiments show that is has possibilities as a contact spray for plant lice and other insects, but has the greatest promise for the control of various animal parasites, particularly, fleas, lice and cattle grubs.

CONCLUSIONS. The roots of Devil's shoe-string *Cracca virginiana*, offer to American Entomologists an opportunity for the development of a supply of fish-poison for insecticidal purposes. The supply at present probably is adequate for commercial purposes but due to the marked variations in the toxicity of the plant, it may not be possible to wholly utilize it. Extensive experimental work should be made on the factors influencing its toxicity, growing and harvesting, and its chemistry, in addition to exhaustive experiments on many forms of insect under both laboratory and field conditions.

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A POWER SPRAY OUTFIT ADAPTED FOR APPLYING SMALL QUANTITIES OF MATERIAL[1]

By F. W. METZGER, *Associate Entomologist*, and A. R. WHITCRAFT, *Agent, Bureau of Entomology, U. S. Department of Agriculture*

ABSTRACT

The paper describes a power spray outfit which can be used for applying small quantities of material under field conditions. It was used extensively and satisfactorily during the summer of 1930, over 2,500 gallons of spray material being applied.

A large number of chemicals and plant extracts have been tested against the Japanese beetle by applying them in spray form on various kinds of foliage.[2] These substances were tested on large peach trees which required from 3 to 5 gallons of spray material per tree, and also on smaller peach and apple trees where the quantity necessary for a thorough application was from 2 quarts to 1½ gallons. From one to three trees were used in testing each material.

During the summer of 1929 over 300 small peach and apple trees were sprayed and 150 of these received two applications. Over 100 larger peach trees were also treated, each receiving two applications. All spraying was done by means of a bucket pump.

NEED FOR IMPROVED EQUIPMENT. The task of applying so much material by a hand pump was particularly laborious and, in addition, the pressure obtained was too low to give a satisfactory coating of the foliage. This was especially true in the case of the upper branches of the larger peach trees. Another difficulty encountered was the lack of proper agitation.

[1]Contribution No. 83 from the Japanese Beetle Laboratory, Moorestown, New Jersey.

[2]Metzger, F. W. Methods Used in Testing Materials as Repellents for the Japanese Beetle. Jour. Agr. Research, Vol. 40, No. 7, pp. 659–671, 1930, illus.

At the close of the beetle season of 1929 it was obvious that considerable work of the same nature would again be necessary during the next year. In an attempt to improve the method of applying the sprays, a study was made of the various small spray outfits then on the market, but as none appeared entirely suitable for the work it seemed advisable to devise an apparatus which would meet all the needs of this particular type of spraying.

The fundamental requirements for such an outfit appeared to include the following: comparatively low capacity with fairly high pressure, a small tank which could be easily cleaned, proper agitation at all times, and a compact arrangement of the component parts so that the entire apparatus could be mounted on a light motor truck.

DESCRIPTION OF OUTFIT. After investigating several types of pump and engine units which appeared suited for spraying, it appeared that an apparatus of the type used to pump water in rural homes was particularly adapted for the required use. The pump was of the piston type mounted on an iron base 6 by 30 inches and coupled to a single cylinder, one-half horse-power, 4-cycle gasoline engine. An endless V-belt connected engine and pump. The engine was equipped with a foot starter which was much easier to operate than a hand crank or a rope starter attached to the fly-wheel.

In order to facilitate mounting in a truck, the spray unit was bolted to a heavy wooden base 3 feet square which was in turn fastened to the bottom of the truck. A 10-gallon wooden keg having one end open was mounted on the base and served as the spray tank. The bottom of the keg was elevated 12 inches above the base and the outlet of 1-inch pipe ran from an opening in the bottom to the intake of the pump. (Fig. 54, S) The outlet was screened to prevent the pump from becoming clogged.

A relief valve (Fig. 54, V_1) set for 75 pounds pressure per square inch was attached to the ¾-inch outlet from the pump. As the motor was run at a speed which developed more than 75 pounds pressure, there was a constant return of the spray material to the tank through a ¾-inch return pipe (Fig. 54, R_1) connected with the relief valve. The end of this return pipe was located near the top of the tank. The pump outlet (Fig. 54, 0) then led across the bottom of the base where a pressure gauge was attached to the line, beyond which the hose attachment and shut-off (Fig. 54, C) were located. From this point the line ran up to another valve (Fig. 54, V_2) which was left slightly open when spraying was in progress and thus caused a further return of material to the tank. (Fig. 54, R_2) The end of this pipe was near the bottom of the tank so

that the spray material was agitated by R_1 from above as well as R_2 below. This method of agitation proved to be satisfactory in all cases. Its efficacy was tested by filling the tank with lead arsenate at the rate of 3 pounds to 50 gallons of water and spraying 1 gallon into each of ten buckets. The material was then allowed to settle, but between the buckets there was no appreciable difference in the quantity of lead arsenate.

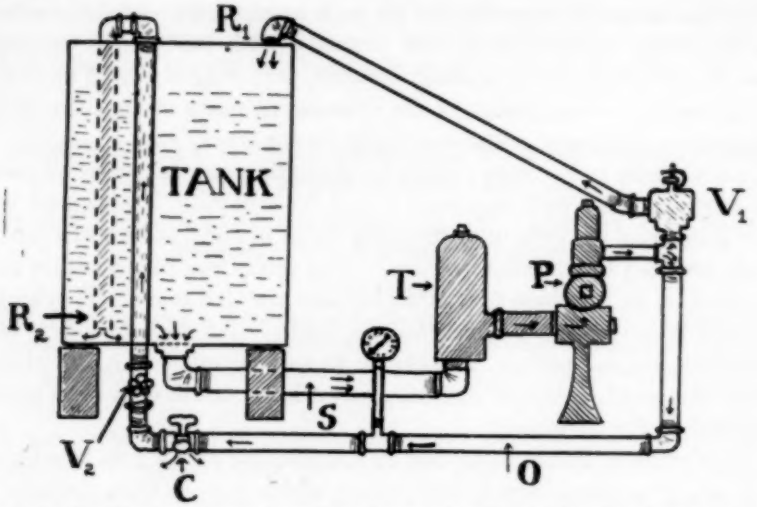

FIG. 54.—Cross-section of pump and connections. (S) Suction from tank to pump. (T) Pressure chamber. (P) Pump. (V_1) Relief valve. (R_1) Return pipe to top of tank. (O) Outlet from pump. (C) Hose connection and shut-off. (V_2) Valve permitting additional material to return to tank. (R_2) Return pipe to bottom of tank. Arrows indicate course of spray material.

A 20-foot length of hose and a standard spray gun were used at all times, and the outfit was run at a capacity of 3 gallons per minute. This enabled the operator to thoroughly cover a tree before the material was exhausted. The pump and tank were rinsed with water between applications of different substances. Fifty gallons of water contained in 5-gallon tins was carried in the forward part of the truck.

The total cost of the apparatus exclusive of the truck was approximately $100. This figure includes labor charges in attaching the various fittings.

USE DURING THE SUMMER OF 1930. This apparatus was used extensively in experimental work during the summer of 1930 and over 2,500 gallons of spray material were applied on approximately 450 peach and

Plate 24

Outfit in operation.

apple trees. It is estimated that 1,000 gallons of water were also pumped in cleaning and rinsing, as over 300 different materials were used, the majority being applied on two or more different occasions. Plate 24 illustrates the outfit in operation.

With the exception of a few minor adjustments, no trouble was experienced in operating this outfit, and at the end of the season, both pump and engine were in excellent condition. The spraying was done in a satisfactory manner and with a considerable saving in labor as compared with the cost of similar work done during previous years.

A NEW AUTOMATIC INSECT TRAP FOR THE STUDY OF INSECT DISPERSION AND FLIGHT ASSOCIATIONS

By F. A. FULTON, *Agent*, and JOSEPH C. CHAMBERLIN, *Associate Entomologist*

ABSTRACT

An insect trap which automatically receives and retains the insects borne by a representative moving current of air is described, and its application to studies of insect dispersal and flight associations, with especial reference to the sugar-beet leafhopper (*Eutettix tenellus* Baker) is discussed. Traps were operated from spring to fall of 1930 in the Twin Falls-Jerome beet territory of southern Idaho, and the data secured demonstrate the fact that the influx of the beet leafhopper was with the prevailing westerly and northwesterly winds. They further showed that this movement was continuous throughout the season.

In the course of studies upon the possibilities of direct control of the sugar-beet leafhopper (*Eutettix tenellus* Baker) in its breeding grounds prior to migration to the beet fields, it became important to ascertain and accurately delimit those breeding areas which actually are of positive economic significance in the supplying of leafhoppers to the cultivated areas.

According to Carter[1] "damage is proportional to distance from the desert areas, irrespective of compass point." However, direct field observation has shown that when leafhippers are flushed in a breeze they may tend at first to fly a few feet against the air current but they then invariably turn and fly with the wind. Furthermore the prevailing direction of the wind in the territory under consideration (Twin Falls, Jerome, and Burley districts) at the time of the influx of the leafhoppers into the beet fields was from the west and northwest during 1930 and, as shown in a separate contribution,[2] the incidence of leafhopper damage

[1]Carter, Walter. Ecological Studies of the Beet Leaf Hopper. U. S. D. A. Technical Bulletin 206, Nov. 1930, p. 67.

[2]Studies of *Eutettix tenellus* (Baker) in Southern Idaho for 1930. Annand, Chamberlin, Henderson, and Waters.

and population has been exactly what might have been expected if the leafhoppers were assumed to be carried into the territory as more or less passive particles with this wind.

It was in consequence felt that if some trap could be devised which would automatically present its effective face into the wind, correlation of leafhopper catch, wind direction, and location of suspected areas would yield much positive information as to the actual contributions and hence importance of given breeding grounds. In addition, by mounting these traps at various elevations data should be yielded as to the height of flight of the insect.

The first trap devised was merely a modification of the sheet of paper covered with a tree-banding material frequently used in the past in the study of insect dispersion.[3] This trap, in order to avoid as much air obstruction and deflection as possible, was made of a 24 x 16 inch sheet of "8-to-the-inch" mesh galvanized hardware cloth covered with a special slow-drying glue composed of partially vulcanized vegetable oil compounded with a small quantity of rosin. The trap was mounted on one end of a weather vane and freely suspended from suitable arms attached at various elevations on a slender pole and further provided with ropes and pulleys to permit raising and lowering.

A trap similar to this but employing a tree-banding material has since been described by Hull[4] in connection with trapping plant lice.

It may be noted in passing that, in the summer and spring climate of southern Idaho at least, ordinary tree-banding material is ineffective in catching beet leafhoppers. They have been observed to alight upon and immmediately fly off the surface of this material without the slightest apparent inconvenience.

A battery of nine three-trap stations employing the traps just described was set up and maintained throughout the spring (May) and summer of 1930. The data thus obtained on the sources and duration of the leafhopper migration are being reported in full elsewhere. Suffice here to say that the results secured showed that the incoming leafhopper migration during 1930 (probably dissemination is the better word) was positively correlated with the prevailing westerly and northwesterly winds. They were further conclusive in showing that for the present year at least the migration was practically continuous throughout the entire summer.

[3]Quayle, H. J. The Red or Orange Scale. University of California College of Agriculture, Bulletin 222, 911 pp. 99–129.

[4]Hull, Frank H. Some Methods of Trapping Plant Lice. Jl. Economic Entomology. Vol. 23 (No. 4) p. 715, figs. 1 and 2, Aug., 1930.

A wide variety of insects was obtained in addition to *E. tenellus*. Unfortunately the removal of insects from the glue employed usually resulted in mutilation such that specific or even generic determinations were extremely difficult. It was, however, evident that the flight associations thus represented might be of great theoretical or practical ecological significance. For instance, a typical collection classified primarily to order and selected at random from a host of similar records shows a very interesting association of trapped insects.

Trap 1 M, June 5, 1930 (24-hour catch). Seven *Eutettix tenellus* (Baker), 8 other leafhoppers, 3 Hemiptera, 2 Neuroptera, 3 aphids, 3 Coleoptera, 5 Diptera.

The collections from the individual traps show a marked variation from day to day. For example, even on the day following, June 6, 1930 the same trap just noted yielded a collection which differed markedly in certain respects from the one just itemized: i.e. 9 *E. tenellus* (Baker), 3 other leafhoppers, 14 Hemiptera, 4 aphids, 3 Coleoptera, 15 Diptera, 1 hymenopteran.

In spite of the evident value of the data secured, a number of undesirable features in the traps was early evident. First and foremost, their proper daily care involved an almost prohibitive amount of labor. During the rush season in early June a force of three men was kept continuously employed in taking care of our battery of nine stations and twenty-seven traps. This was owing partly to the fact that a 100-mile trip had to be made to take up the collections, and also to the fact that the picking and preserving of the insects from the glue was very laborious and time-consuming. The insects were picked off by forceps, dropped into carbon tetrachloride for cleaning, and finally transferred to alcohol for preservation. The screens had then to be cleaned and fresh glue applied. Cleaning involved boiling and scrubbing the entire trap in hot concentrated lye water. Furthermore it was found that the glue developed a glazed or varnished surface within 24 to 48 hours of exposure to sun and wind and almost wholly lost its efficiency. Long runs were hence impossible. Rain invariably would destroy the holding capacity of the glue. A truck of considerable carrying capacity was necessary to transport the screens to and from the field.

As a result of these difficulties a second type of trap was developed and perfected which eliminated most of these objectionable features. This trap is shown in Plate 25, Figs. 1, 2, and the structural details are shown and fully described in Fig. 55. This trap is an adaptation of the industrially familiar "wire maze" (Air-Maze) type of apparatus for air filtration and purification, and comprises essentially a short tubular

air passage provided with a parallel series of off-set screens through which the air moves. A series of eddy currents results within the maze thus formed, and tends to so direct the insect's movements that it ultimately works its way downward into a funnel which in turn empties into a glass cyanide jar. The mesh of the series of screens progressively decreases in the direction of the air current, the only essential factors being that it be large enough in the first place to permit the passage of the largest insect it is desired to trap, and small enough in the last place to retain the smallest insect desired. Surrounding the entrance screen is

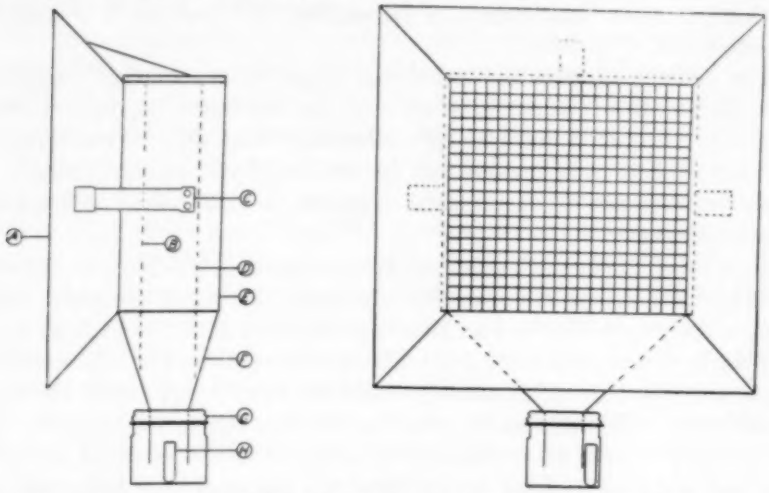

FIG. 55.—A, Baffle Plate; B, Hardware cloth 1/8"; C, Angle brace; D, 16 mesh wire screen; E, 22 mesh wire screen; F, Funnel; G, Screw cap for Mason Jar and H, Cyanide bag.

a funnel-like baffle plate which is designed to concentrate the air flowing through the trap with resultant accentuation of the eddy currents. Orientation with the wind is obtained as in the previous model by suitable vanes. Free rotation can be provided in a number of ways. The method now being adopted is that of either mounting or suspending the trap from a fixed bearing (see Plate 25) taking care to see that the center of gravity is held very low. Raising and lowering a trap so mounted (Plate 25, 1, 2) is obviously impractical and suitable means are provided for scaling the pole.

These, as well as traps of the former design, will operate efficiently and well both in a gentle breeze and in moderate gale without danger of breakage. With the new trap of course a slight breeze is necessary for proper functioning.

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The advantages of the perfected trap include unimpaired efficiency over any desired period of time; its efficiency at the end of a week's exposure, for example, is equal to its efficiency at the start of the run. Except in rainy weather the collections may be emptied into small boxes and treated exactly like net collections. In rainy weather the insects are best removed from the trapped water and preserved in alcohol. Rain does not decrease the efficiency of this trap. The trapped insects are in all cases in unmutilated condition for study. The laborious cleaning process necessary with the old glue-type trap is obviated and no large carrying capacity is needed in order to run a long circuit. The labor of taking care daily of a 100-mile line provided with from 25 to 50 separate traps is certainly less than one-third or one-fourth that necessary to handle the same line using the old glue-type traps.

The efficiency of this trap is as great as that of a fresh glue-type trap. The following summary of two trap catches, for instance, will be seen to be quite comparable with the collections previously noted for traps of the old type. A disadvantage of this trap is that the supporting pole must be of sufficient strength to permit climbing.

Trap 6-M, September 18, 1930. (Trap 16 ft. above ground.) One *E. tenellus*, 3 other leafhoppers, 4 aphids, 21 Hemiptera, 6 Hymenoptera (winged ants), 3 Coleoptera, 2 Diptera, 1 neuropteran.

Trap 6-T, September 18, 1930. (Trap 24 ft. above ground.) One *E. tenellus*, 2 other leafhoppers, 15 aphids, 19 Hemiptera, 5 Hymenoptera, 4 Coleoptera, 0 Diptera, 2 Lepidoptera (small moths), 1 neuropteran.

While designed primarily for use where automatic response to wind direction is desired, this trap, properly mounted, should be equally effective in a fixed position. For instance, in a case where fluctuating winds occur over short periods of time a set of four or more of these traps mounted in a square or circle and oriented with the cardinal directions should automatically record, in the resultant catches, the percentage of insects coming from any given direction.

Scientific Notes

Cotton Boll Weevil has no Hibernation in Laguna District of Mexico.—Evidence is at hand indicating that the cotton boll weevil, *Anthonomus grandis* Boh., does not have a true hibernation period in north-central Mexico. At Tlahualilo, Durango, Mexico, February 17, 1931, a weevil freshly emerged from the pupa was recovered in a pink bollworm moth trap on a hibernation cage. This cage had been placed over dry cotton bolls two days before. The cotton bolls had been picked the preceding fall and were in a loose layer on top of the soil with no protection. The weevil was soft and had apparently recently issued from the pupa. February 28, 1931, 3 live pupae were found while cutting open dry cotton bolls for pink bollworm recovery.

These were alive and in good condition. March 16, 1931, two old weevils were taken from a flight screen in a field formerly in stubble cotton which had been plowed under about a month. Tlahualilo is located to the north of Torreon in a high desert plateau about 3,700 feet above sea level. Cotton is raised by means of irrigation, the annual rainfall being less than 9 inches.

C. S. RUDE, *Assistant Entomologist, Bureau of Entomology, Cotton Insect Investigations*

The Pickle Worm in Chayote in Porto Rico. The pickle worm, *Margaronia nitidalis* Cramer, the well known pest of cucumbers, melons, squashes and gourds in Florida and other places where these crops are grown has been found by the writer breeding in chayote, *Sechium edule*, in Porto Rico. Wolcott in his "Insectae Portoricensis" (1923) gives as the only records for Porto Rico those made by Gundlach (as *Phacellura*) Möschler, and by Stahl (as *P. hylinasalis*) but no host plant or definite locality are mentioned.

The writer found the first infested chayote fruits at Lares in October 1930. An inspection at one of the largest plantings in that locality showed some 20% of the fruit to be infested at the seed, only one caterpillar being found per fruit. In some of them there were also a few short tunnels made from the outside into the flesh of the fruit by the caterpillars. From October 1930 to March 1931 the infestation as could be judged by inspection of the fruit at the Río Piedras market was only 5 to 10 per cent. In April, a large fruit was picked from a vine on the Station grounds in which not only the seed but all of the flesh had been ruined by the tunnels of apparently several caterpillars, and a smaller fruit in which the seed alone had been destroyed.

During the month of January, 1931, a plot of about one fourth of an acre of cucumbers was harvested on the Station grounds. The fruits were heavily infested with the melon worm, *Margaronia hyalinata* Linn., but not a specimen of the pickle worm was found among them.

FRANCISCO SEIN, JR., *Assistant Entomologist, Insular Expt. Station, P. R.*

The Effect of the Sun on Plum Curculio Larvae in Peach Drops.—Peach drops are usually picked up from commercial peach orchards in the South and buried or otherwise destroyed as a supplementary control measure for the plum curculio. The question has been raised as to the effect of the sun on curculio larvae in drops in a peach orchard if they were brought out from under the trees to the middles where they would be exposed to the direct sun rays. In order to answer that question the following experiment was conducted during the 1930 season. On April 29 one peck of peach drops, heavily infested with curculio larvae, was spread out in a thin layer on top of 5 inches of clay soil in each of two large boxes which had been constructed especially for the experiment. One of the boxes was placed in the middle of a lot where the drops were exposed to the sun rays during the entire day. The other box was placed in the shade under large pecan trees, similar to shady places in woodlands where peach drops are sometimes thrown by careless orchard laborers. Daily records were then kept of the adult curculio emergence from each box. Even though during the curculio pupation period chickens disturbed the soil in the box which was under the trees, 167 plum curculio beetles emerged from it between June 7 and August 6. In all probability the chickens ate some of the larvae and pupae in that box, while other pupae were prevented from developing as a result of the soil being

disturbed during the pupation season. Not a single beetle emerged during the season from the box which was exposed to the sun. The soil in that box was in no way disturbed during the course of the experiment.

OLIVER I. SNAPP and J. R. THOMSON,
U. S. Peach Insect Laboratory, Fort Valley, Georgia

The Eggs of the Lima Bean Pod Borer in Porto Rico.—*Maruca testulalis* Geyer (Lepid., Pyralidae). In the course of our preliminary study of the lima bean pod-borer we were unable to find any reference to the eggs of this species ever having been found or described. Up until the time of completing MS for a paper on "A preliminary report on the lima bean pod-borer and other legume pod-borers in in Porto Rico" (Jour. Econ. Ent. 24 (2): 466–73, 1931) we had been unable to find the eggs.

On December 5, 1930, a lepidopterous egg was found on the calyx of an unopened bean blossom at Rio Piedras which we judged might be the egg of this pod-borer since 5% of the blossoms by actual count in a small planting were infested by young Maruca larvae. The egg did not hatch but a description was made of it.

In late January, 1931, a small percentage of the pods in an acre planting of string beans at the Insular Station was infested. A number of pupae from these larvae were placed in a cheese cloth cage containing a potted bean plant. At the time of emergence of the moths the plant had blossom-buds and blossoms but no pods had formed. On February 13 several eggs were found on the leaves and blossom-buds. By February 18 all of the blossoms had fallen off without forming pods. About 20 more eggs had been laid. These were mostly on the upper surface of the leaves but a few were on the lower leaf surface and on the stems.

The egg is greenish white, usually oval but sometimes almost circular in outline, scale-like but rather noticeably convex with reticulated markings on the corium, which is semi-shining.

Measurements of several eggs averaged 0.5 mm. in width and from 0.6 to 0.8 mm. in length. As hatching approaches the color becomes more yellowish and the blackish head of the young larva can be distinguished within.

A. S. MILLS, *Junior Plant Quarantine Inspector*, and
M. D. LEONARD, *Chief Entomologist, Insular Experiment Station, Rio Piedras, P. R.*

Research on Kerosene Extracts of Pyrethrum.—Concerning the insecticidal method for the estimation of kerosene extracts of pyrethrum (Jour. Econ. Ent. *24* (1): 97–105, 1931) it is suggested that more uniformity in the results may be obtained by placing the treated flies in a constant temperature and humidity box (75°F, 50% humidity) for the 24 hours following the application. It is also suggested that this method is applicable for the testing of water emulsions of pyrethrum extract provided a suitable wetting agent is present in the spray.

A short summary of the remaining part of this thesis, which was submitted to the graduate faculty of Iowa State College in partial fulfillment of the requirements for the Ph.D. degree, is given as follows:

Various fractions of kerosenes were found to vary materially in their insecticidal power. A light fraction (48° Baume, 310–395° F. boiling range) was decidedly slower in its speed of paralytic action and much less toxic in its final kill than a heavier fraction (41° Baume, 378°–516°F. boiling range). Little difference was

noted in a series of three short-cut fractions between 400° to 500° F. boiling range. Kerosenes refined with liquid sulfur dioxide (Edeleanu refining process) showed little difference in toxicity from other fractions of the same boiling range.

The efficiency of a kerosene extraction of pyrethrum powder was found to vary considerably with the degree of fineness of the powder. As indicated by insecticidal tests, the efficiency of kerosene extraction on 15, 20, 30, and 45 mesh pyrethrum powders did not vary materially; approximately 75–80% extraction being obtained. Extraction was significantly more efficient on 200 mesh powder; 90% extraction being obtained.

Tattersfield and Hobson's short acid method for the analysis of pyrethrin I was found to give reproducible results and with a series of various pyrethrum powders the pyrethrin I content was found to give a reliable index of the insecticidal power of kerosene extracts of these powders. This was also found to be true with deteriorated pyrethrum powders.

Relative to the stability of kerosene extracts of pyrethrum, no deterioration could be detected in extracts which had aged for twelve months, as indicated by insecticidal tests.

Other experiments indicated that normally a considerable number of flies which had been completely paralyzed by a kerosene extract of pyrethrum (of the usual household spray strength) recover over a period of 5–15 hours after the application. The fertility of these flies was unaffected. They laid fertile eggs which in turn gave rise to fertile adult flies, the progeny of which were also fertile and of normal size. Pyrethrum extract appeared to have little repellent action toward house flies.

A new technique of rearing house flies was developed. Experiments indicated that the flies reared in this way were most resistant (as judged by the final mortality) from 24–48 hours of age; after this their resistance decreased. On the other hand the flies' resistance to the paralytic action of pyrethrum extracts was least at the younger age; increased as they grew older. It is intended to publish this research in more detail in the near future.

HENRY H. RICHARDSON, *Investigator, Crop Protection Institute, Zoology Dept., Iowa State College, Ames, Iowa*

The *Euonymus* Scale.—In 1880 specimens of scale infested Euonymus were received by J. H. Comstock from Norfolk, Virginia with the observation that serious injury was commonly inflicted by the species. Investigation showing it to be an unnamed form, he described it as *Chionaspis euonymi* (Ann. Rept. U. S. Com. of Agri. **1880:** 313). In its type locality, the species has apparently given *Euonymus* little respite in the past fifty years. It is today virtually the only important factor limiting the cultivation of this otherwise popular shrub.

An oil spray applied during the dormant season of the plant is the control measure commonly recommended for Euonymus scale (Jour. Econ. Ent. 4:259, 1911; and others). We applied a 1 to 10 strength of Scalecide to *Euonymus japonica* on February 25, 1930, at a time when some of the leaf buds were opening. It gave rather good control. Injury to the new leaves, however, was common and later a considerable number of short twigs dropped.

Apparently the possibilities of fumigation with hydrocyanic acid gas have never been explored. In 1905 W. E. Britton wrote, "This species.... was abundant on *Euonymus radicans* along a brick wall. The wall was covered with canvas, and the plants fumigated with hydrocyanic gas." (Conn. Bul. **151:** 10). We have been

unable to find other reports on the fumigation of *Euonymus*. In February 1930, several heavily infested *E. japonica* shrubs were treated *in situ* with hydrocyanic acid gas generated from Calcium cyanide (A Grade Cyanogas). The plants which were about 5 feet tall and four feet in diameter were enclosed by a fairly tight fumigatorium composed of a light wooden frame and heavy wrapping paper. One-half ounce and one ounce per 100 cubic feet were dosages used, while the exposure period was one hour. Treatments were made during the afternoons of February 14 with the temperature 47° F. and relative humidity 79 and five days later when the temperature was 68°F., relative humidity 42. Scale control was nearly complete with the 1 ounce application and no injury occurred to the bushes. A plant fumigated February 19 with one-half ounce $Ca(CN)_2$ showed the poorest kill although this was estimated at 98%. Such are our preliminary findings. Unfortunately these studies have had to be discontinued but possibly others may care to investigate further.

Early in the spring the bodies of the insects enlarge and the differentiation of the eggs is noticeable. On April 4, 1930 scales were found to contain as many as 126 large eggs. The first newly hatched nymph was found April 22. The bodies of 17 scales, at the time eggs were first being laid late in April, contained from 60 to 157 eggs or an average of 98 eggs per scale. (Other scales on another occasion were found with as few as 8 or 10 eggs.) The egg of the euonymus scale is elongate, smooth, orange yellow, and measures .22 by .11 mm.

P. J. CHAPMAN
M. M. PARKER
G. E. GOULD
Virginia Truck Experiment Station

***Leptoglossus gonagra* Fab. Injuring Citrus in Porto Rico.**—During the latter part of November, 1930, the writer, in company with Mr. Richard Faxon of the U. S. Plant Quarantine and Control Administration office in San Juan visited the farm of Mr. H. E. Avery of Pueblo Viejo to investigate injury to oranges first noticed a few days previously. Upon examination the insect in question proved to be *Leptoglossus gonagra* Fab. This is apparently the first record of its being injurious to citrus.

The grove in which the insects were working comprised about 65 acres of bearing trees. The bugs were abundant over the whole planting and the winged adults could be found with ease on the fruits, often several on the same fruit and occasionally almost as many as the surface of the fruit would accommodate at one time. Nymphs were sometimes found on the fruits but only where the vine on which they were naturally feeding had grown up and reached the lower branches so that it was possible for them to crawl on up into the trees.

The bugs seemed to be attracted only to ripening fruits and there were a good many beginning to show color at that time. In extracting the juice by means of the beak small pale and watery spots on the surface were made. This watery discoloration was much more pronounced upon cutting into the skin and below it a small area of drier cells in the pulp was produced extending for a considerable distance in towards the center. Often a slightly rotten odor could be detected in the pulp so affected and the fruit had a somewhat bitter taste. Apparently a number of feeding punctures caused the fruits to fall but the loss from "drops" was not very great.

The natural food-plant of this leaf-footed plant-bug seemed to be a curcubitaceous vine, the wild balsam apple, or as it is locally called, the "Cundeamor" (*Momordica*

charantia L.). This was growing all over the grove in a rank tangle among a volunteer cover-crop of grasses and other weeds and furnished an excellent breeding place and a continued source of infestation. The nymphs could be found in large clusters feeding upon this weed and several batches of eggs were also noticed.

R. T. Cotton (Jour. Dept. Agr. Porto Rico 2 (1), 1918, had previously very briefly described the eggs but a somewhat more detailed description may here be desirable. The eggs are dark brown, dull, with a slightly shagreened appearance in certain lights, cylindrical, but flattened on the surface of attachment. They are placed end to end and lie on their sides in rows of several up to 12 or 14. Each egg measures almost 1.4 mm in length by about 1 mm in diameter. One egg-mass was found on a blade of "malojillo" grass which was abundant in the grove but as far as could be determined the bugs were not feeding on this grass. The nymphs emerge through a circular hole situated at one end of the egg and almost one-half the length of the egg in diameter. The nymphs are at first a bright tomato red with black legs and antennae, but in the last two stages (presumably 4th and 5th) the predominating color is a dull brownish with the flattened tibiae almost as pronounced as in the adult.

Two or three days previous to our visit the writer had recommended over the telephone that the whole cover crop including specially the "cundeamor" vines, be removed as speedily as possible and we found the tractors and disc harrows busy at work upon our arrival. Mr. Avery had a quantity of "Red Arrow," a pyrethrum-oil contact spray, on hand and preliminary tests conducted with this material showed that when the bugs were well wet with the spray a dilution of 1–600 would kill at least 90% of the adults on the fruit. At first attention was directed to killing the bugs on those trees which had fruits beginning to show color, using one of the large power spray machines. This was found to be wasteful of material so several men were put in the grove with small compressed-air sprayers with which the spray could be thoroughly directed to killing the adults on the individual fruits upon which they were feeding. Both nymphs and adults were also sprayed when they were found still alive on the cut piles of the cover crop. On a second visit made about a week later there were very few of the bugs remaining in the grove and it was felt that the situation was well in hand. Mr. Avery stated in March, 1931, that it had taken about a month to eliminate all of the bugs from his grove and that there were still a few fruits on the trees bearing the signs of previous injury.

Only one other case of injury to citrus could be located at this time. This was in a tract of about 10 acres of grapefruit a little west of Bayamon, belonging to Capt. T. R. D. Barbour. Although we did not personally inspect this grove the owner told us that the injury was similar to that done to the oranges in Pueblo Viejo and that about 10% of the fruit had fallen. Prompt removal of the volunteer cover crop and spraying had, he said, prevented further damage.

About the middle of November Mr. A. S. Mills of the Federal Plant Quarantine Service reported slight injury to the pods of lima beans and the fruit of tomatoes near Rio Piedras due to the feeding of this plant bug.

Leptoglossus gonagra as an injurious insect is apparently little known. It was first described by Fabricius in Ent. Syst., p. 708, 1775, from the "West Indes." It has been recorded from most of the Islands in West Indies and from Mexico and Central America as well as from Brazil and the Argentine in South America. In Van Duzee's Catalogue of the Hemiptera it is listed from Florida. Search through the literature, however, has disclosed but one record of it being injurious outside of Porto Rico. In 1918 it was briefly recorded as injuring tomatoes and bonavist beans on the

Island of St. Vincent (Huston, J. C., Report of a visit to St. Vincent during November and December, 1917). A preliminary report on certain plant bugs connected with cotton in St. Vincent.—Colonial Office MS., See R. A. E. 6:251. R. T. Cotton (l. c.) briefly discusses it as a squash bug in Porto Rico. Wolcott, in his "Insectae Portoricensis" (Jour. Dept. Agr. Porto Rico 7 (1): 250–251, 1923 (1924), lists it as occurring on weeds in canefield in 1912 at Rio Piedras; on corn at Sabana Llana in 1915 and on *Cleome spinosa* Jacq., the spider flower or 'Jasmin del Rio,' very abundant at Cayey (Cotton, 1916);" also listed by Gundlach at San Juan.

Several other leaf-footed plant bugs have been recorded as injurious. *L. australis* has injured cotton in the Bismark Archipelago (R. A. E. 1:349). *L. balteatus* is a general feeder on tomatoes and bonavist beans in St. Vincent, B. W. I., but also feeds on cotton (R. A. E. 6: 250). *L. oppositus* and *zonatus* are recorded as cotton feeders in the United States and the latter has prevented the growing of pomegranates on a commercial scale in Arizona where it also sometimes attacks oranges and ripening peaches (R. A. E. 1:180). *Leptoglossus phyllopus* L. is a well known pest at times of citrus in Florida and several of the other Southern States. It also attacks Irish potatoes (R. A. E. 7:418) and tomatoes (R. A. E. 3:179) in Florida; and has been recorded as injuring cotton squares in the United States (R. A. E. 6: 248) and the globe artichoke (normal food plant is the yellow thistle) in Louisiana (R. A. E. 7:79). *L. membranaceous* Fab. has been recorded as a citrus pest in Queensland (severe damage) (R. A. E. 8:156) and also in South Africa. It is also injurious to beans in Ceylon (R. A. E. 14:424); to cotton in Tanganyika (R. A. E. 14:424 and 11: 531) and in Uganda (R. A. E. 7:260); to beans (R. A. E. 14:424) and to various fruits and vegetables (R. A. E. 1:89) in Ceylon; and to curcubits in the Philippines (R. A. E. 5:515) and in East Africa (R. A. E. 11:366).

M. D. LEONARD, *Chief, Division of Entomology,*
Insular Experiment Station, Rio Piedras, Porto Rico

Food Preferences of Grasshoppers. Due to an accident some interesting data were obtained on the food preferences of two species of grasshoppers, *Melanoplus bivittatus* Say and *Melanoplus differentialis* Thomas. Several egg pods of these two species were placed in a cage in a greenhouse, and on hatching, the nymphs were reared on tender spring wheat and Wandering Jew (*Tradescantia*). When approximately 50% of the nymphs were about half grown, the wide rubber strip acting as a door, snapped, allowing from 50 to 75 grasshoppers to escape. Of the 26 kinds of plants present in the greenhouse at the time, only two, a citrus and a palm, were eaten upon to any great extent but these were heavily attacked. The palm, especially, in spite of the tough, stringy nature of the fronds, suffered great injury. Below is listed the plants present and the injury sustained.

Name of plant	*Degree of injury*
Citrus—Grape fruit	Heavy
Palm—Washingtonia?	Very heavy
Agave americana	None
N. Z. Hemp (Sanseveria zeylanica)	None
Hypericum aureum	Slight
Cactus—echinocactus	None
" —undetermined	None
Nerium oleander	Slight

Name of plant	*Degree of injury*
Sempervivum	None
Berberis vulgaris (purple)	Slight
Sago palm (Cycas revoluta)	None
Yucca glauca	None
Bryophyllum cruentum	Slight
Oxalis corniculata	None
Portulaca oleracea	None
Sonchus arvensis	None
Wheat (Triticum vulgaris)	Slight
Dianthus carophyllus	None
Geranium (Pelargonium)	None
Tetragonia expansa	None
Coleus thyrsoideus	None
Begonia 2 varieties	None
Petunia violacea	None
Fuschia	None
Pansy (Viola tricolor var. hortensis)	None
Potatoes (Solanum tuberosum)	Slight

G. ALLEN MAIL, *Montana State College, Bozeman, Montana.*

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ANNUAL SCIENTIFIC MEETINGS: 1931-1932, New Orleans; 1932-1933, Atlantic City.

This issue completes the Proceedings of the Forty-third Annual Meeting and clears the way for the publication of the Proceedings of the various branches, preferably in chronological order. The Editor takes this opportunity of urging authors to get their papers in final form and in the hands of the respective secretaries early. Publication, sometimes prompt publication, is urgently desired by many and yet not a few are slow about turning in their papers. They fail to realize that a Secretary may wish an opportunity to assemble papers before forwarding them to the Editor. The latter must have some time if he is to discharge his duties satisfactorily. Authors are not infrequently located on the Pacific Coast. The supplying of omissions, the fixing up of illustrations and other problems requiring adjustment can not be attended to quickly when the parties are widely separated. In this connection, we would call the attention of Branch officials and the members generally to the arrangement for publication approved by the Executive Committee, accepted by the Association and published on page 10 of the February issue. It is a step toward systematizing our methods. It is commendable in that it is elective rather than compulsory. The Proceedings of the general meetings will take precedence over other matter as heretofore. There is no reason why those of the various branches should not appear in a somewhat well recognized sequence. It would do no harm for authors to read the Rules and Suggestions respecting copy on the third cover page. Familiarity with these is an aid to preparing acceptable copy.

Obituary

FERDINAND F. CREVECOEUR

FERDINAND F. CREVECOEUR, an amateur entomologist and naturalist who has been the source of many insect records from Onaga, Kansas, died suddenly on April 7, 1931. He was buried in the Onaga cemetery. Mr. Crevecoeur was born at Chicago, Illinois, June 23, 1862. Following the death of his father, he, in April, 1870, came with his mother to live on a farm near Onaga, Kansas, where he lived until his death. He remained a bachelor and lived alone after his mother's death in 1908. A United States Department of Agriculture Yearbook came into his possession, which opened up to him a field of biological science and geology. He had much correspondence with officials of the United States Department of Agriculture, who gave him much encouragement. The U. S. Department of Agriculture, the Smithsonian Institution and the National Museum sent him their publications in the biological and geological fields. To these services and the Kansas Academy of Science he gave the major credit for his technical knowledge and encouragement.

In 1917, Mr. Crevecoeur gave practically all of his natural history collection to Ottawa University, Ottawa, Kansas. As an amateur, he published quite extensively. There have been published several more or less popular articles in the Onaga Republican, one article in Entomological News, 1903, and nine articles in the Transactions of the Kansas Academy of Science (1903–1922). A biography and also a bibliography has been prepared by Dr. Roger C. Smith for publication in the Transactions of the Kansas Academy of Science.

R. L. PARKER

Current Notes

A. B. Baird, of the Dominion parasite laboratory, Belleville, Ontario, visited the Bureau of Entomology gipsy-moth laboratory on April 25.

C. F. W. Muesebeck, of the Bureau of Entomology gipsy-moth laboratory, completed in April a manuscript entitled "Revision of the Nearctic Ichneumon-Flies Belonging to the Genus Macrocentrus."

Weather conditions in the Saskatoon Sask., district have been quite extraordinary and reports in the press of insect activities have been common, referring particularly to grasshoppers and certain butterflies.

Dr. F. S. Bodenheimer, of Palestine, visited the taxonomic unit, National Museum, on March 14 to 17. He is especially interested in scale insects, but discussed various problems with specialists in the unit.

D. S. Bullock, of Angol, Chile, was in the Division of Insects in the National Museum March 20 to discuss the insects of his region. He was especially interested in the Chilean Coleoptera.

August Busck, of the section of Lepidoptera, U. S. National Museum, has just received from Edward Meyrick, well-known lepidopterist of Marlborough, England, over 100 determined species of South American Microlepidoptera, including some cotypes.

The Annual Dinner of the Thomas Say Entomological Society of Purdue University was held April 15, at which time Dr. W. S. Blatchley addressed the Society on the subject, "The Days of a Naturalist."

A. B. Gahan, Bureau of Entomology, of the section of Hymenoptera, recently completed an exchange with the Naturhistorisches Museum of Vienna, through which he added to the collections about 200 determined species of Chalcidoidea, mostly European.

H. H. Shepard, Assistant Entomologist at the Takoma Park, Md., Bureau of Entomology, field laboratory, resigned, effective March 31, to accept a position in the department of entomology and zoology at the University of Minnesota, St. Paul, Minn.

James B. Majure, who has completed the requirements for the B. S. degree at the Mississippi, A & M College, was appointed Field Assistant, Bureau of Entomology, at the Peach Insect Laboratory, Fort Valley, Ga., and reported for duty on March 23.

Dr. R. B. Friend, Assistant Entomologist of the Connecticut Agricultural Experiment Station, who for several years has given instruction in Entomology in Yale University, has been promoted to the grade of assistant professor.

Mr. Neely Turner, who since November 10, 1927, has been engaged in research on oil sprays for the Crop Protection Institute, and stationed at New Haven, Conn., has been appointed Assistant Entomologist of the Connecticut Agricultural Experiment Station, beginning June 1, 1931.

On April 23, R. E. Campbell and M. W. Stone, of the Alhambra, Calif., Bureau of Entomology field laboratory, had charge of two demonstrations on methods of wireworm control under the auspices of the Ventura County, Calif., Extension Service.

Arrangements have been made with Mr. William E. Hoffman, of Lingnan University, Canton, China, whereby he will make a monthly report on insect conditions in China, the report to be published in the monthly bulletin of the Insect Pest Survey.

D. E. Fink, Entomologist, Bureau of Entomology, in charge of the insecticides laboratory at Philadelphia, Pa., visited Washington, April 6 and 7, to confer with Bureau officials in regard to the proposed transfer of his laboratory from Philadelphia, Pa., to Takoma Park, Md.

J. A. Beal, Bureau of Entomology, of the Portland, Ore., field Laboratory, has completed his report on studies of insects developing in logging operations in western yellow pine. This study was based upon tractor logging on the Weyerhaeuser operation near Klamath Falls.

Dr. S. A. Graham, Professor of Forest Entomology at the University of Michigan has been appointed visiting Professor of Entomology at the Ohio State University for the summer term 1931 and will teach insect ecology and direct research work in this field.

On March 16, E. R. Van Leeuwen, Bureau of Entomology, returned to his regular duty at the Japanese Beetle Laboratory after a furlough of three and one-half months, during which period he was engaged as an instructor for the Davey Tree Expert Company of Kent, Ohio.

Norman Allen, Junior Entomologist, Division of Truck Crop Insects, Bureau of Entomology, Baton Rouge, La., was a visitor at the field laboratory at Tallulah, on March 23. Mr. Allen was principally interested in flight-screen and airplane collections of the striped cucumber beetle.

Mr. Arthur Gibson, Dominion Entomologist of Canada, attended the 18th Annual Meeting of the New Jersey Mosquito Extermination Association held in Atlantic City, New Jersey, Feb. 18–20. At this meeting Mr. Gibson presented a paper on the progress of Mosquito investigations in Canada during 1930.

A. M. Vance, Bureau of Entomology, who has been assigned for several years to the corn borer parasite laboratory at Hyeres, France, returned to the United States April 13. After spending several days in Washington Mr. Vance went to Arlington, Mass., where he will be assigned to work on corn-borer parasites.

Frank G. Hinman, Bureau of Entomology, recently appointed Junior Entomologist to assist A. O. Larson in the pea-weevil investigations, with headquarters at Corvallis, Oreg., has translated from the German, F. Zacher's important publication, "Biology of Seed Beetles (Bruchidae-Lariidae)." A copy of this translation is being filed with the Bureau Library at Washington.

The following appointments were made in the Cereal and Forage Division, Bureau of Entomology, during March: Ralph Bunn, John L. Joy, Richard C. Newton, and Leland J. Jones, Junior Entomologists, for duty at Salt Lake City, Utah; Frank Lieberman, Field Assistant at Salt Lake City; and Ralph Schopp, Field Assistant at Toledo, Ohio.

Charles C. Plummer, was appointed Assistant Entomologist, Bureau of Entomology, effective April 15, for duty at Cuernavaca, Mexico. Mr. Plummer has had previous experience in the Bureau in work with the European corn borer in Connecticut, and also in the Truck Crop Division in work on the Mexican bean beetle in Mexico.

M. C. Swingle, Bureau of Entomology, was transferred from the Japanese-beetle laboratory at Moorestown, N. J., where he was engaged in investigations of parasites, to the deciduous-fruit insects field laboratory at Takoma Park, Md. Mr. Swingle will be engaged in physiological and toxicological investigations of parasites under the general direction of Dr. F. L. Campbell.

John L. Gardiner, Bureau of Entomology, who for the past eight months has been stationed at the Brownwood, Tex., pecan insect laboratory, was transferred May 15 to Harriman, Tenn. There he will be associated with H. G. Butler in investigations of the oriental fruit moth, the plum curculio, and the peach borer in the eastern Tennessee region.

On March 20 T. C. Barber, Bureau of Entomology, took up his work on the cotton leaf perforator at Calexico, Calif. En route from Brownsville, Tex., he spent several days at Tucson, Ariz., completing his report on last year's experiments in the Imperial Valley and conferring with T. P. Cassidy on plans for this season's work.

Owing to the peculiarities of the season and the absence of snow, with some thawing, it has been possible to carry on field studies of cutworms in the Strathroy, Ontario, district of Canada. These studies indicate cutworm feeding, even in February, thus explaining the disparity in size between autumn larvae and those found when the season opens.

On April 20 M. H. Brunson and T. R. Gardner made a trip through lower New England to make studies of local conditions at various points of Japanese-beetle infestation, with particular reference to the possibility of distribution of parasites. During the course of their trip they made short visits at the gipsy-moth and corn-borer laboratories near Boston.

C. W. Collins, Bureau of Entomology, in charge of the gipsy-moth laboratory, gave a talk concerning its activities before the Boston U. S. D. A. Club on March 24. In connection with his talk, three motion-picture films of the Department of Agriculture were shown. These films have to do with the life histories of the gipsy and brown-tail moths, their parasites, and methods of control.

William Middleton, Bureau of Entomology, left Washington the latter part of March in company with F. L. Mulford, of the Bureau of Plant Industry, to make an inspection of fourteen national cemeteries in the southeastern part of the United States. The inspections will serve as a basis for recommendations to the War Department for improving the condition of the trees in those cemeteries.

T. R. Gardner and J. W. Balock, Bureau of Entomology, of the Japanese Beetle Laboratory, made a scouting trip to Rutherford, N. J., on April 14, in search of infestations of *Aserica castanea* and *Anomala orientalis*. Dense local infestations of these insects were located in sufficient numbers to warrant introduction of the Aserica parasite *Tiphia asericae*. It is planned to introduce the parasite this spring.

Mr. R. E. Snodgrass, in charge of insect morphology, Bureau of Entomology, has just completed on April 15th his course in insect morphology, at the University of Maryland. This is the second time the course has been offered, and it is hoped that there will be a sufficient number of students to continue the work next year. Mr. Snodgrass is Collaborating Professor of Entomology at the University.

W. E. Shull, Assistant Entomologist, College of Agriculture and Agricultural Extension Division, University of Idaho, has been granted a leave of absence until September, 1932, to take advanced work at the Iowa State College, where he was awarded a fellowship beginning March 25, 1931. Mr. Paul Rice has been appointed Assistant Entomologist for the Agricultural College and the Agricultural Experiment Station during the period of Prof. Shull's leave.

Arrangements have been made to ship *Macrocentrus ancylivorus*, a valuable North American parasite of the oriental fruit moth, to the French Government. The first shipment of 1,000 cocoons was made on April 24. This shipment was taken from Moorestown, N. J., to New York City by H. W. Allen and placed on board the Italia American Corporation boat "Augustus." It will be received by G. J. Haeussler and M. Balachowsky in southern France.

The weather in the Lethbridge, Alberta, area has been so mild that Mr. G. F. Manson, Entomological Branch, spent Feb. 5–8, in the Orkney district, in field work on the wheat stem sawfly and pale western cutworm. During the latter half of January the weather was so warm that many insects, particularly hibernating

beetles, were active, and on Jan. 30 Mr. R. M. White made a collection of active grasshopper nymphs which were later forwarded to Mr. Criddle.

Mr. J. Harvey Roberts, who for the past year has been a teaching fellow at the University of Maryland, has accepted a position as instructor in entomology at the Louisiana State University, Baton Rouge, La. Mr. Roberts will receive his M. S. degree from the University of Maryland this year. He is a graduate of the University of Wisconsin, and went from there to Louisiana State University, where he was formerly an instructor before taking graduate work at Maryland.

B. H. Wilford, under temporary appointment with the Bureau of Entomology reported for duty in Coeur d'Alene on March 2. He will have charge of the field operations in connection with a study of the spruce budworm which is to be conducted within the Cody Canyon, Wyo., during the coming season. The purpose of this study is the development of a method of control which will be both effective and economical in the protection of trees which have high scenic values.

Dr. W. G. Campbell, in charge of insect physiology and toxicology, Bureau of Entomology, has been appointed Collaborating Professor of Entomology at the University of Maryland, College Park, Md. Dr. Campbell will offer a course next year in insect physiology. The course will be taught in the late afternoon, and will start in November and continue through to the middle of the following April. It is a one semester course, but overlapping two terms in order to accommodate field workers and others.

C. E. Hood and J. V. Schaffner, jr., of the Bureau of Entomology gipsy-moth laboratory were in North Andover, Mass., on April 21 making observations on leafminer injury to spruce. On April 23 Mr. Schaffner visited the towns of Harpswell, Southport, Boothbay and Bristol on the Maine coast for the same purpose. The observations so far made indicate that *Epinotia nanana* Tr. is the predominant species. Mr. Hood is continuing the control experiments with sprays, which were begun last year, and A. B. Proper will carry on life-history studies with the species concerned.

On March 28 Dr. Henry H. Richardson was appointed Assistant Entomologist, Bureau of Entomology, to assist in the investigations of greenhouse insects at the Tropical Green House in Washington. Dr. Richardson was formerly temporary Field Assistant, under Dr. F. A. Fenton, on the cotton boll weevil investigations. He was later appointed Junior Entomologist and assigned to gipsy-moth work at the Melrose Highlands, Mass., field laboratory. He resigned from this position in 1928 to take up graduate work at the Iowa State College and received his doctor's degree in March of this year.

Luther Brown, Bureau of Entomology, who for the past few years has been stationed at the field laboratories at Sligo and Takoma Park, Md., and who for the past two years has been engaged in rearing parasites of the codling moth, was transferred to Albany, Ga., in early April. At the Albany laboratory he will be associated with Dr. Herbert Spencer in investigations of the utilization of Trichogramma in the control of the nut case-bearer and other pecan insects. The work will include a general investigation of the parasites of various pecan insects.

On March 6 control work on the western pine beetle was started in Sequoia National Park. Two camps have now been established, and it is expected that work

in three tributary watersheds of the Kaweah River will be completed by May 1. Supt. White and Mr. Coffman of the National Park Service were at the Berkeley laboratory on March 6 to make final plans with the Bureau of Entomology for the execution of this project. Albert Wagner was assigned by the Bureau of Entomology to direct the training of the control crews in spotting methods and treatment of trees.

A report covering the 1930 season's experimental work on the fir engraver beetle (*Scolytus ventralis*) was completed by G. R. Struble, Bureau of Entomology, during February. The report includes a study of losses in white fir, the life history of *S. ventralis*, and studies on a fungus associated with *S. ventralis*. Experimental work in the laboratory on high temperatures as they affect the larvae of *S. ventralis* show that their lethal point is about 5 degrees higher than that for the larvae of *Dendroctonus brevicomis*. Tests on the development of *S. ventralis* larvae at constant temperatures show a wider range of development than for the larvae of *D. brevicomis*.

R. Wooldridge, Bureau of Entomology, of the gipsy-moth laboratory, spent March 23 and 24 at an isolated gipsy-moth infestation in Milan, N. Y. Milan is about 9 miles east of the Hudson river in the so-called "gipsy moth barrier zone." The special object of Mr. Wooldridge's trip was to secure information concerning any natural enemies that might be present in the infestation. Puparia of two tachinid flies, *Compsilura concinnata* Meig. and *Sturmia scutellata* R. D., were found. The discovery of the presence of the latter is of particular interest because the laboratory has no records of the parasite having been previously taken in New York State.

The following recent appointments have been made in the Bureau of Entomology: Fred A. Morton, Junior Entomologist, for duty at Bozeman, Mont., M. V. Anthony, Field Assistant, at Arlington Farm, Va., Walter C. Baker, Field Assistant, at Arlington, Mass; Fred J. Coy, Field Assistant, at Craig, Colo.; Franklin S. Blanton, Junior Entomologist, for duty at Babylon, N. Y.; R. H. Davidson and F. W. Fletcher have been appointed as Agents and assigned to duty at Columbus, Ohio, to assist with the Mexican bean beetle project. The following field assistants have also been appointed: H. G. Bergen, Twin Falls, Idaho; D. H. Brannon, Walla Walla, Wash. H. L. Dees, Picayune, Miss.; and E. C. Murdock, Grand Junction, Colo.

Mr. Ralph Hopping, Entomological Branch, has been spending some weeks in Ottawa working over a programme of investigational work in British Columbia for the coming season with Messrs. Swaine and deGryse. He left headquarters to return to his laboratory at Vernon, B. C., on March 6. During 1931, under Mr. Hopping's direction, an intensive population study will be carried out in connection with the bark beetle outbreak which spread from lodgepole pine into yellow pine stands over the southern interior of British Columbia. This work will deal largely with *Dendroctonus monticolae* Hopk., the principal species involved. Particular stress will be laid on the cause of the spreading of this insect from one species of pine to another.

Investigations during the coming summer in British Columbia will be continued by Mr. W. G. Mathers, Entomological Branch, on the spruce budworm outbreak on balsam fir in the Barkerville district, and on the outbreak of *Dryocoetes confusus* Sw., which has followed the spruce budworm attack. The spruce budworm infestation in the above district has continued since 1923, when the Branch records were commenced. The striking feature of this outbreak is that it occurs in a two-year cycle consisting of a fairly intensive outbreak one year which dies down the next.

Evidence collected in 1930, indicates this phenomenon to be due to a two-year life cycle of the insect species, the explanation for which is apparently associated with weather conditions in that region. Further investigations in this connection are to be made this year.

The Yosemite National Park started its control program in the yellow-pine belt on March 16. In an inspection of this area on March 14 and 15, Dr. Salman, of the Bureau of Entomology, found that an increase of the western pine beetle had developed late in the fall of 1930 on national forest lands adjoining the park boundaries. This condition threatens the Wawona Road screen, a strip of timber sheltering the road through the park from the adjacent cutover lands. Conditions were found to be similar to those on other areas of the Southern Sierra region where epidemics have recently developed. An allotment was promptly made by the Forest Service to carry on control work in conjunction with that within the national park. Mr. Baumhofer and Dr. Salman will assist in carrying out this project.

C. W. Collins, I. T. Guild, and W. L. Baker, of the gipsy-moth laboratory, Bureau of Entomology, spent April 7 at Amherst, Mass., consulting with C. E. Behre and V. E. Jensen, of the Northeastern Forest Experiment Station, regarding a joint report now being prepared that deals with a series of silvicultural plots in different kinds of typical forest stands in that part of New England infested by the gipsy moth. This project was begun as the result of a cooperative agreement entered into between the Bureau of Entomology and the Forest Service in 1913. Its objects were to ascertain what proportion of trees of different species could be associated to form stands which would not be subject to gipsy-moth ravages, and to determine the best methods of converting existing stands into others better able to resist attack.

The Bureau of Entomology annual spring survey of larval conditions in various stations within the areas heavily infested by the Japanese beetle was begun in April under the supervision of Dr. Henry Fox. The results to date indicate that, in the older areas conditions are much as in 1930, except that the larvae appear to be more uniformly distributed at various topographic levels than was the case in 1930, when a pronounced tendency to congregate at low elevations was evident. This year the indications are that the concentration in low tracts in southern New Jersey is more pronounced than in the sections about Moorestown and Philadelphia. These differences are accounted for on the basis of the varying amounts of rainfall, the concentration at low levels being most pronounced in sections where drought during the period of maximum hatching was most severe.

A reconnaissance of areas along the western front of the Sequoia and Sierra National Forests was made during the week of March 30 to April 4 by J. M. Miller and Dr. K. A. Salman, of the Palo Alto, Calif., Bureau of Entomology bark-beetle laboratory. They were accompanied on this trip by T. D. Woodbury of the Forest Service and Willis Wagener, of the Office of Forest Pathology. Forest officers had reported a heavy loss of yellow pine during the past winter within this area, which includes a narrow strip, approximately 100 miles in length, just above the brush belt. It was found that the western pine beetle was rapidly increasing throughout this area. There has been a deficiency of precipitation in this region for the two preceding seasons, followed by very dry conditions during the winter of 1930–1931. This may have been a contributing factor in the recent bark-beetle epidemic.

Horticultural Inspection Notes

A conference and School for Horticultural Inspectors of the State of Utah was held at Salt Lake City in February.

The inspection of express, parcel post, and freight in transit through Pittsburg has recently been instituted primarily for the enforcement of the European corn borer quarantine regulations.

Mr. C. F. Campbell of the Department of Agriculture of Pennsylvania has been transferred from inspector in the western counties to supervisor of insecticide and fungicide survey and investigation.

Tentative plans have been worked out to hold the next meeting of the Section of Plant Quarantine and Inspection of the Association of Economic Entomologists at New Orleans on the afternoon and evening of Tuesday, December 29.

Scouting for the discovery of the Mediterranean fruit fly in Florida was discontinued by the Plant Quarantine and Control Administration of the United States Department of Agriculture on March 31. The Orlando office of the Administration is being closed and the equipment transferred to other branches of the government service.

Messrs. G. W. R. Davidson and J. M. Corliss of the Plant Quarantine and Control Administration, assisted the State inspectors of North Carolina, Tennessee, Illinois and Indiana in the discovery and diagnosis of narcissus bulb pests for several days in May.

A conference of narcissus bulb growers and State Nursery Inspectors of the State of Washington was held at Tacoma on April 3 and 4. The importance of vigorously continuing the activities directed toward the suppression of bulb eelworms and bulb flies was emphasized.

The New York office of the European corn borer project has been moved from 45 Broadway to 641 Washington Street, New York City, and combined with the Japanese beetle office already at that location. The consolidated office is under the supervision of Mr. Leland Wolfe.

Messrs. N. O. Berry and R. G. Oakley, who have been employed on Mediterranean fruit fly eradication work in Florida, have recently been transferred to the Port Inspection Service of the Plant Quarantine and Control Administration and assigned to duty at San Juan, Porto Rico.

The appropriation for the Oklahoma State Plant Board for the period from March 1 to July 1, 1931, was vetoed by the Governor. Provision has, however, been made for the biennial period from July 1, 1931 to June 30, 1933. The personnel of the State Plant Board remains the same as heretofore.

Messrs. A. C. Johnson, W. T. Hunt, J. M. Luckie and A. G. Galloway have been engaged for the past several months, under the direction of Doctor Lon A. Hawkine of the Plant Quarantine and Control Administration, in work directed toward the improvement of the efficiency of car fumigation on the Mexican border.

In consideration of the repeal of the former plant quarantine law of Texas and the passage of a new statute on this subject, public hearings have been held in the Lower Rio Grande Valley following which it is planned to reissue the Mexican fruit worm proclamations under the new legal provisions now in effect.

The State of Massachusetts has increased to 210 the number of towns in which the further planting of currant and gooseberry bushes is forbidden. The purpose of the action is to set aside these towns as white-pine-growing and Ribes-free areas and thus to assist in the prevention of spread of blister rust in the State.

Transit inspection activities under the Plant Quarantine and Control Administration, at St. Paul, Omaha, Kansas City, Portland, Seattle, Odgen, and Denver have been discontinued for the summer. The certification of peach nursery stock at Concord, Ga., was discontinued the first of May, the peach nursery stock shipping season having closed. This work has been carried on during the fall and winter under the phony peach disease quarantine regulations.

Mr. S. A. Rohwer, on April 1, terminated his connection with the Plant Quarantine and Control Administration to become Assistant Chief of the Bureau of Entomology of the United States Department of Agriculture. A Civil Service examination for filling the position of Assistant Chief of the Plant Quarantine and Control Administration has been announced by the Civil Service Commission, the receipt of applications for which was closed on May 13.

The Commissioner of Agriculture and Commerce of Porto Rico on April 21, 1931, amended the Porto Rican regulations for the suppression of the pink bollworm of cotton which is established on that Island. Under the revised restrictions all Sea Island cotton plants growing in the southern part of the Island from May 15 to June 30 inclusive, are ordered destroyed, and all Sea Island cotton plants growing in the northern part of the Island are destroyed from October 15 to June 1, inclusive.

The recently published annual report of the California State Department of Agriculture for the calendar year 1929 records the interception of twenty-two separate lots of contraband material arriving on airplanes at the Port of San Diego from various points in Mexico. One important interception consisted of tufts of straw caught in the tail gear of an airplane from Sonora, the straw being found to be infested with a serious nematode pest of rice and grain known as *Tylenchus angustans*. This particular pest is not known to occur in the State of California.

A full and detailed report of the Mediterranean fruit fly eradication project carried out by the United States Department of Agriculture in cooperation with the State Plant Board of Florida is included in the monthly bulletin of the latter Board for March, 1931. The report includes a list of the host plants of the Mediterranean fruit fly as determined by cage experiments at Orlando, Florida, prepared by Mr. C. B. Keck, under the direction of Doctor A. C. Baker of the Bureau of Entomology. Records of the infestations and of the expenditures and a synopsis of the changes in the Federal and State regulations governing the suppression of the Mediterranean fruit fly and the interstate movement of articles to prevent its spread are also presented.

The Pennsylvania Department of Agriculture reports that the enforcement of the cedar rust act has resulted in the removal of approximately 100,000 cedar trees during the past two years, mainly in Adams and Franklin Counties on the southern border of the State. Under the Plant Pest Act, compensation to the extent of seventy per cent of the appraised value of all cedar trees removed is authorized. Changes in inspection policy by the same Department for the coming season include the transfer of the supervision of raspberry inspection to the Division of Pathology of the Department and the inauguration of a system of special inspection for all trees

susceptible to poplar canker infection during the month of May when the disease is most easily recognized.

A revision of the rules and regulations governing the movement of plants and plant products into and out of the District of Columbia was announced by the Secretary of Agriculture on April 30, 1931, to become effective on the same date. Under the revision annual and vegetable plants may hereafter enter and leave the District without inspection and certification except such as may be required under the Japanese beetle regulations and other special quarantine orders. Herbaceous perennial plants, bulbs, and roots will also hereafter be admitted into the District without being certified in advance in the State in which they were produced. Perennials will be inspected upon arrival and, if found free from injurious insect pests and plant diseases, delivery to the addressee will be permitted.

Recent changes in the quarantine regulations of Oregon, according to Mr. Charles A. Cole, Secretary of the State Board of Horticulture, include (1) the addition of the States of Kentucky, Ohio, Illinois and Michigan to the list of States from which most deciduous fruits and fruit trees are forbidden to enter the State on account of the Oriental fruit moth, (2) the addition of Virginia, Tennessee, South Carolina, North Carolina and Louisiana to the territory from which the entry of potatoes is restricted on account of the potato tuber moth, and (3) the amendment of the grape Phylloxera quarantine so as to require an inspection certificate from point of origin certifying that the section is free from Phylloxera, and, if the plants are stored elsewhere, there must also be a certificate stating that the point of storage is free from Phylloxera.

Under an order issued on December 16, 1930, the Department of Agriculture and Labor of Porto Rico removed the restrictions on the importation of all kinds of vegetable and flower seeds and all kinds of fruits and vegetables in their raw state with the exception of citrus fruits. Citrus fruits from the Gulf States are prohibited movement into Porto Rico on account of the citrus canker, and such fruits when originating in Arizona and California are prohibited entry to the island on account of the various species of scale insects. Similarly, the importation into Porto Rico of lily bulbs, narcissus, hyacinths, tulips, buds and grafts of fruit-bearing trees; nuts, including those of palms, and the seeds of fruit trees, shade, forest and ornamental trees originating in the Gulf States continues to be prohibited.

Apiculture Notes

Dr. J. H. Merrill, Raynham Center, Massachusetts, was elected to Honorary Life Membership in the American Honey Producers' League at the 1931 annual convention held at Toronto, Canada.

A. L. Freeland, of Dunkirk, N. Y., has been appointed temporary field assistant, Bureau of Entomology, and reported for duty April 16 at the Bee Culture Laboratory, Somerset, Md.

The library of the Division of Bee Culture is indebted to E. G. Carr, Secretary-Treasurer of the New Jersey Beekeepers' Association for completing its files of "New Jersey Bee Culture," a publication devoted to the development of beekeeping in New Jersey.

The ninth annual convention of the North Dakota Beekeepers' Association and short course in beekeeping was held in conjunction with Farmers' and Home-

makers' Week at the North Dakota Agricultural College, Fargo, January 21–22. Out of state speakers included H. G. Ahrens, University of Minnesota; E. W. Atkins of the G. B. Lewis Company, Watertown, Wisconsin, and Miss Helen L. Pickard of the Kellogg Company, Battle Creek, Michigan. The Association voted to continue its affiliation in the American Honey Producers' League and members pledged financial support to the American Honey Institute.

A joint program featured the annual convention of the American Honey Producers' League, the American Honey Institute, the Ontario Beekeepers' Association, the Apiary Inspectors of America, and the Ontario Honey Producers' Cooperative held at the Royal York Hotel, Toronto, February 9–13, inclusive. New officers in the League include James Gwin, President, Madison, Wisconsin; F. J. Buck, Vice-President, Walla Walla, Washington; and V. G. Milum, Secretary-Treasurer, Champaign, Illinois. One of the important steps taken was to change the constitution, by which Canada is now placed on an equal basis with the United States and makes the League international in scope.

Notes on Medical Entomology

On March 2 Arthur W. Lindquist was appointed Junior Entomologist, Bureau of Entomology, and assigned to duty at the Uvalde, Tex., field Laboratory.

George H. Bradley, Bureau of Entomology, of the Orlando, Fla., field laboratory, spent April 18 to 30 investigating the recent destructive outbreak of Simulium in Mississippi and Arkansas.

F. C. Bishopp, Bureau of Entomology, spent April 22 and 23 in a survey of the mosquito control work now being conducted by State officials in New Jersey.

G. E. Bell was appointed Laboratory Assistant, Bureau of Entomology, and entered upon duty at the field laboratory at Charleston, S. C., on March 6. He will be engaged in investigations of sand flies.

On March 13 D. C. Thurman was appointed Agent, Bureau of Entomology, and entered upon duty at Menard, Tex. Mr. Thurman is assisting in trapping tests for control of blowflies on the cattle range.

R. A. Roberts, Assistant Entomologist, Bureau of Entomology, of the Uvalde, Tex., field Laboratory, spent practically the entire month of April in Mexico, investigating and collecting parasites of blowflies for possible importation into the United States.

On April 11 F. C. Bishopp and T. P. Cassidy, both of the Bureau of Entomology, were present at a conference held with the Texas Experiment Station authorities at College Station, Tex., on the investigations of the sheep scab and the goat louse.

F. S. Mulock, of the United States Smelting, Refining, and Mining Company, Boston, Mass., accompanied by George S. Tulloch a graduate student of Harvard University, arrived in Washington recently for a series of conferences with F. C. Bishopp and other Department officials on the proposal to conduct a cooperative investigation of the mosquito problem in the vicinity of Fairbanks, Alaska. Tentative plans were laid for Mr. Tulloch to undertake the field work under Mr. Bishopp's direction.